Code No: 43141/43142 **R07** **Set No - 1**

II B.Tech I Semester Regular Examinations,Nov/Dec 2009
THERMODYNAMICS
Common to Mechanical Engineering, Aeronautical Engineering, Automobile Engineering

Time: 3 hours **Max Marks: 80**

Answer any FIVE Questions
All Questions carry equal marks

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1. (a) Explain a heat engine cycle performed by a steady flow system with line diagram.
   (b) Show by second law that the dissipation of electrical work into internal energy or heat is irreversible. [8+8]

2. (a) Energy is a point function. Explain and prove.
   (b) Prove that heat and work are path functions. [8+8]

3. (a) What are adiabatic and diathermic walls?
   (b) The flow energy of 0.124 m^3/min of a fluid crossing a boundary to a system is 18 KW. Find the pressure at this point. [6+10]

4. A gas refrigerating system using air as a refrigerant is to work between -11^{o}C and 26^{o}C using an ideal reversed Brayton cycle of pressure ratio 6 and minimum pressure l atm, and to maintain a load of 11 tonnes. Find
   (a) the COP
   (b) the air flow rate in kg / s
   (c) the volume flow rate entering the compressor in m^3/s and
   (d) the maximum and minimum temperatures of the cycle. [16]

5. For air conditioning a room in winter, atmospheric air at 6 ^{o}C and relative humidity 22% is first heated in a heating coil. It is then passed through a spray water till the relative humidity becomes 90%. The humidified air is again heated sensibly to the conditioned state in the room at 21.5^{o}C and 32% relative humidity. If the atmospheric pressure is 1 bar, determine per kg of dry air
   (a) the amount of heat required during the process, and
   (b) the amount of water evaporated in the spray water unit respectively. Compute also the humidifying efficiency of the spray water unit. Plot the process on the psychrometric chart. [16]

6. (a) Explain the significance of Vander walls equation and its limitations
   (b) A tank of volume 1.3 m^3 is filled with argon at 6 bar and 260^{o}C. If the gas within the tank changes its state isentropically when it flows from the tank until the pressure drops to the atmospheric pressure of 1 bar, determine the mass of the gas that has left the tank during the process. [6+10]

7. A dual combustion cycle operates with a volumetric compression ratio $r_k = 12$, and with a cut-off ratio 1.615. The maximum pressure is given by $P_{max} = 54\ P_1$ where P_1 is the pressure before compression. Assuming indices of compression and expansion of 1.35, show that the m.e.p. of the cycle $P_m = 10\ P_1$ Hence evaluate

   (a) temperatures at cardinal points with $T_1 = 335$ K, and

   (b) cycle efficiency. [16]

8. (a) What is normal boiling point and explain its significance.

   (b) Steam flows in a pipe line at 1.5 Mpa. After expanding to 0.1 Mpa in throttling calorimeter, the temperature is found to be 120^0 C. Find the quality of steam in the pipe line. What is the maximum moisture at 1.5 Mpa that can be determined with this set-up it at least 5^0c of super heat is required after throttling for accurate readings? [6+10]

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Time: 3 hours **Max Marks: 80**

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1. A slow-speed reciprocating air compressor with a water jacket for cooling approximates a quasi-static compression process following a path $pv^{1.35}$ = constant. If air enters at a temperature of 23°C and a pressure of 1.1 bar, and is compressed to 6.5 bar at a rate of 1050 kg/h, determine the discharge temperature of air, the power required and the heat transferred per kg. [16]

2. (a) Demonstrate, using the second law, that free expansion is irreversible.
   (b) A domestic food freezer maintains a temperature of -15^0 C with ambient temperature of 30^{0}C. If heat leaks into he freezer at the continuous rate of 1.75 kJ/s, What is the least power necessary to pump this heat out continuously. [8+8]

3. (a) What is an air standard cycle? Why are such cycles conceived?
   (b) Find the air standard efficiencies for Otto cycles with a compression ratio of 6 using ideal gases having specific heat ratios 1.35, 1.43 and 1.62. What are the advantages and disadvantages of using helium as the working fluid? [6+10]

4. (a) Explain microscopic and macroscopic approach with examples.
   (b) A pump forces 1.2m/min of water horizontally from an open well to a closed tank where the pressure is 0.9 Mpa. Compute the work the pump must do upon the water in an hour just to force the water into the tank against the pressure. [6+10]

5. Air at 28 °C, 78% RH is cooled by spraying in water at 10 °C. This causes saturation, followed by condensation, the mixing being assumed to take place adiabatically and the condensate being drained off at 17.5°C. The resulting saturated mixture is then heated to produce the required conditions of 55% RH at 23°C. The total pressure is constant at 101 kPa. Determine the mass of water supplied to the sprays to provide 12 m^3/h of conditioned air. What is the heater power required? [16]

6. A 6 ton ideal vapour compression refrigerator works between the condensing pressure of 12 bar and evaporating pressure of 3.3 bar. The refrigerant is dry saturated vapour before it enters the compressor. Saturated liquid refrigerant enters into the expansion valve from the condenser. The average specific heat of the superheated refrigerant vapour at constant pressure is 1.7 kJ /kg K. Compute the temperature of the refrigerant before it enters the condenser, the refrigerating effect per kg of refrigerant, the COP, the mass flow rate of the refrigerant per minute and power

input into the compressor.

The properties of the refrigerants are:

Pressure bar	Sat. Temperature ^{0}C	Enthalpy kJ/kg	Entropy kj/kg K	
		Sat. liquid (h_f)	Sat. liquid (S_f)	Sat. vapour (S_g)
12	30	84.5	0.312	0.9
3.3	-12	31	0.125	0.95

[16]

7. A rigid vessel contains 1 Kg of a mixture of saturated water and saturated steam at a pressure of 0.15 Mpa. When the mixture is heated, the state passes through the critical point. Determine the volume of the vessel, the mass of the liquid and vapour in the vessel initially, the temperature of the mixture when the pressure has risen to 3Mpa, and the heat transfer required to produce the final state. [16]

8. (a) Explain what is PMMI?

   (b) Steam enters a steam turbine with a velocity of 16 m/s and specific enthalpy 2990 kJ/kg. The steam leaves the turbine with a velocity of 37 m/s and specific ethalpy of 2530 kJ/kg. The heat lost to the surroundings is 25 kJ/kg with the steam flow rate of 3,60,000 kg/w. Calculate the turbine work output in kW. [4+12]

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1. (a) Explain the air standard Otto cycle with the help P-V and T-S diagrams.
   (b) In an Otto cycle, the upper and lower limits for absolute temperatures are respectively T_3 and T_1. Show that for maximum work, the ratio of compression should have the value
   $r = (T_3 / T_1)^{1.25}$ Take $\gamma = 1.4$ [8+8]

2. (a) Write the unit of temperature and explain the International fixed points.
   (b) Explain in detail the ideal gas temperature scale. [8+8]

3. Two containers p and q with rigid walls contain two different monoatomic gases with masses m_p and m_q gas constants R_p and R_q, and initial temperatures T_p and T_q respectively, are brought in contact with each other and allowed to exchange energy until equilibrium is achieved. Determine:
   (a) the final temperature of the two gases and
   (b) the change of entropy due to this energy exchange. [16]

4. (a) Show that the adiabatic mixing of two fluids is irreversible.
   (b) Show that if two bodies of thermal capacities $C_1$and C_2 at temperatures T_1 and T_2 are brought to the same temperature, T by means of a reversible heat engine, then
   In $T = \frac{C_1 \ln T_1 + C_2 \ln T_2}{C_1 + C_2}$. [8+8]

5. (a) What are the advantages and disadvantages of air refrigeration systems over the other?
   (b) Determine the temperature ratio (T_2 / T_1) (where T_2 = source temperature and T_1 = sink temperature) for a Carnot refrigerator whose COP is 5. Also calculate the refrigeration capacity of the machine in tons of refrigeration if the power consumption is 8 kW. If the cycle is used as heat pump, find the COP for heating cycle and the quantity of heat pumped assuming same temperature range. [6+10]

6. (a) Show that the work done during a flow process is $-\int_{p_1}^{p_2} v dp$
   (b) A certain mass of sulphur dioxide ($S0_2$) is contained in a vessel of 0.145 m^3 capacity, at a pressure and temperature of 24.2 bar and 20°C respectively. A

valve is opened momentarily and the pressure falls immediately to 7.8 bar. Sometime later the temperature is again 20^{o}C and the pressure is observed to be 10.2 bar. Estimate the value of specific heat ratio. [6+10]

7. (a) What is principle of operation of an electrial calorimeter?

   (b) A vessel of 0.04 m^3 contains a mixture of saturated water and saturated steam at a temperature of 250 ^{0}C. The mass of the liquid present is 9 Kg. Find the pressure, the mass, the specific volume, the enthalpy, the entropy and internal energy using steam table only. [6+10]

8. (a) Explain the work interaction between a system and the surroundings.

   (b) The pistion of an oil engine, of area 0.0045 m^2, moves downwards 75 mm, drawing in 0.0028 m^3 of fresh air from the atmosphere. The pressure in the cylinder is uniform during the process at 80 kPa, while the atmospheric pressure is 101.325 kPa, the difference being due to the flow resistance in the induction pipe and the inlet valve. Estimate the displacement work done by the air finally in the cylinder. [6+10]

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1. Two tanks are connected by a valve. One tank contains 1.5 kg of CO gas at 75 ^oC and 0.9 bar. The other tank holds 7.5 kg of the same gas at 25^oC and 1.4 bar. The valve is opened and the gases are allowed to mix while receiving energy by heat transfer from the surroundings. The final equilibrium temperature is 45^oC. Using the ideal gas model, determine
   (a) the final equilibrium pressure,
   (b) the heat transfer for the process. [16]

2. (a) Define the specific heats at constant volume and at constant pressure.
   (b) 1.5 Kg of liquid having a constant specific heat of 2.5 KJ/kg K is stirred in a well insulated chamber causing the termerature to rise by 15^{0}C. Find the change in the internal energy and wotk done for the process. [6+10]

3. (a) What do you understand by the terms refrigeration effect and ton of refrigeration?
   (b) An ideal refrigeration system working on Carnot cycle operates between the temperature limits of -25 ^oC and 30^oC. Find the ideal COP and the power required from an external source to absorb 4 kW at low temperature. If the system operates as a heat pump, determine the COP and the power required to discharge 4 kW at high temperature. [6+10]

4. The usual cooking gas (mostly methane) cyclinder is about 20 cm in diameter and 100 cm in height. It is charged to 11.5 MPa at room temperature of 25 ^oC.
   (a) Assuming the ideal gas law, find the mass of gas filled in the cyclinder.
   (b) Explain how the actual cyclinder contains nearly 15 kg of gas.
   (c) If the cylinder is to be protected against excessive pressure by means of a fusible plug, at what temperature should the plug melt to limit the maximum pressure to 15 MPa? [16]

5. (a) Distiguish between open system and closed system.
   (b) A gas at a pressure of 138 kN/m^2 is having volume of 0.112 m^3. It is compressed to 690 kN/m^2 according to the law pv$^{1.4}$=constant.
   Calcuate the final volume of the gas. [6+10]

6. (a) Explain with the help of a line diagram the cyclic refrigeration palnt.

(b) Prove the equivalence of Kelvin planck and clausius statement. [8+8]

7. Two streams of steam one at 2 Mpa, 300^0 C and the other at 2 Mpa, 400^0 C mix in a stedy flow adiabatic process. The rates of flow of the two streams are 3 Kg/min, 2kg/min respectively. Evaluate the final temperature of the emerging stream, 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 stream with a negligible velocity now expands adiabatically in a nozzle to a pressure of 1Kpa. Calculate the exit velocity of the stream and the exit area of the nozzle. [16]

8. For an air standard Otto cycle with fixed intake and maximum temperatures, T_1 and T_3, find the compression ratio that renders the net work per cycle a maximum. Derive the expression for cycle efficiency at this compression ratio. If the air intake temperature, T_1, is 305 K and the maximum cycle temperature, T_3, is 1300 K, compute the compression ratio for maximum net work, maximum work output per kg in a cycle, and the corresponding cycle efficiency. Find the changes in work output and cycle efficiency when the compression ratio is increased from this optimum value to 8. Take $C_v = 0.718$ kJ/kg K. [16]

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