Code No: RR210304 **Set No. 1**

II B.Tech I Semester Supplementary Examinations, March 2006
THERMODYNAMICS
(Common to Mechanical Engineering and Automobile Engineering)
Time: 3 hours **Max Marks: 80**

Answer any FIVE Questions
All Questions carry equal marks

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1. (a) Discuss the concept of continuum in thermodynamics.
   (b) What do you mean by property? Distinguish between intensive and extensive Properties.
   (c) Discuss where the following quantities can be used as properties are not.
      i. $\int P\ dV + \int V\ dP$
      ii. $\int P\ dV$
      iii. $\int V\ dP$. [4+4+8]

2. In a vessel 10 kg of oxygen is heated in a reversible, non flow, constant volume process so that the pressure of oxygen is increased two times that of the initial value. The initial temperature is 20^oC. Calculate
   (a) the final temperature,
   (b) the change in internal energy,
   (c) the change in enthalpy and
   (d) the heat transfer. Take R = 0.259 kj / kg K and C_v = 0.652 kj / kg K for oxygen. [16]

3. (a) State and prove Clausius inequality.
   (b) Explain the increase in entropy principle.
   (c) A thermal energy source at 800 K loses 2000 kJ of heat to a sink at
      i. 500 K and
      ii. 750 K. Determine which heat transfer process is more irreversible.[6+4+6]

4. (a) Using Maxwell's relations deduce the two Tds equations.
   (b) Derive the equation

$$\frac{(\partial V/\partial T)_s}{(\partial V/\partial T)_p} = \frac{1}{\gamma - 1}$$

[8+8]

5. (a) List out the various non - flow processes when the First law of thermodynamics is applied to closed system.
   (b) Derive the relationship between the two principle specific heats and characteristic gas constant for a perfect gas.

(c) Find the molecular weight and gas constant for the gas whose specific heats are as follows:
$C_p = 1.967$KJ/KgK $C_v = 1.507$ KJ/KgK [6+4+6]

6. A room of dimensions 5m x 3m x 3m contains an air water vapour mixture at 1 bar, 30^0C and 70% relative humidity. Calculate

   (a) Mass of air

   (b) Mass of Water Vapour

   (c) Also find the degree of saturation.

   The universal gas constant is 8.3143 KJ /Kg - Mole K and molecular mass of air and water vapour is 29 and 18 respectively. [16]

7. (a) Draw P-V and T-S diagram of a diesel cycle and explain different processes in the cycle.

   (b) Derive an expression for the efficiency of the ideal cycle for the diesel engine. [8+8]

8. Explain clearly Rankine cycle and derive on expression for thermal efficiency of the cycle. [16]

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1. (a) Distinguish between path function and point function.
   (b) Differentiate between flow and non-flow process. [8+8]

2. One kg of fluid enters a nozzle with a velocity of 300m/min and enthalpy of 2990 kJ/kg. The enthalpy of the fluid at exit is 2760 kJ/kg. The nozzle is placed horizontally and neglects the heat loss from the nozzle. Determine
   (a) The velocity of the fluid at the exit
   (b) The mass flow rate, if the inlet area of the nozzle is $0.095m^2$ and the specific volume at inlet is $0.19m^3$/kg.
   (c) The exit area of the nozzle if the specific volume at exit is $0.5m^3$/kg. [16]

3. (a) State and prove Clausius inequality.
   (b) Explain the increase in entropy principle.
   (c) A thermal energy source at 800 K loses 2000 kJ of heat to a sink at
      i. 500 K and
      ii. 750 K. Determine which heat transfer process is more irreversible.[6+4+6]

4. (a) Distinguish between available energy and availability.
   (b) Air at 1 bar and 30^0C is heated in a reversible manner at constant pressure until its temperature reaches 205^0C. How much of the heat added is available energy (per kg of air heated) if the lowest sink temperature is 4^0C. Also prove the formula used in this calculation. [6+10]

5. (a) Steam initially dry saturated, expands isetropically from a pressure of 16 bar to 0.16 bar. Find the index of isentropic expansion.
   (b) One kg of wet steam at 0.8, 0.1 MPa is contained in a cylinder piston assembly. Energy is added as heat at constant pressure till the temperature is raised to 400^0C. Determine final state of steam and the energy transferred using steam table. Plot the relevant Mollier diagram and obtain the same. [6+10]

6. (a) A gas mixture consists of 60% N_2 and 40% CO_2 by mole basis. Determine the gravimetric analysis of the mixture analysis of the mixture.
   (b) A tank of volume $2m^3$ containing O_2 at 600Kpa and 300K is connected to another tank of volume 3m containing CO_2 at 150kPa and 290K .The gases mix adiabatic ally and come to an equilibrium state. Determine the final temperature and pressure of the mixture and the entropy change for the system. [8+8]

7. In an air standard diesel cycle, the compression ratio is 16, and at the beginning of isentropic compression, the temperature is 15^0C and the pressure is 0.1Mpa. Heat is added until the temperature at the end or the constant pressure process is 1480^0C. Calculate
   (a) The cut off ratio.
   (b) The heat supplied per Kg of air
   (c) The cycle efficiency and
   (d) The mean effective pressure. [16]

8. (a) Sketch the Rankine cycle on P-V and T-S diagram and explain clearly different process of the cycle. State in what respect it differs from carnot cycle working between the same temperature limits.
   (b) Dry and saturated steam at pressure 11 bar is supplied to a turbine and expended isentropicelly to a pressure or 0.07 bar. Calculate the following.
      i. Heat supplied
      ii. Total change of entropy
      iii. Heat rejected
      iv. Theoretical thermal efficiency. [8+8]

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1. A new temperature scale in degrees N is to be defined. The boiling and freezing points on this scale are 400^o N and 100^oN respectively.
   (a) Correlate this with
      i. Centigrade scale and
      ii. Fahrenheit scale.
   (b) What will be the reading on new scale corresponding to 60^oC. [16]

2. A cylinder fitted with a piston has an initial volume of $0.1m^3$ and contains nitrogen at 150kpa, 25^0C. The piston is moved to compress the nitrogen until the pressure is 1 Mpa and the temperature is 150^0C. The work done on the nitrogen is 20kJ. Determine the amount of heat transfer from the nitrogen. [16]

3. (a) Enunciate the two classical statements of second law of thermodynamics.
   (b) One kg of water is heated at a constant pressure of 0.7 MPa. The boiling point is 164.97^0C and the latent heat of evaporation is 2066.3 kJ/kg. If the initial temperature of water is 0^0C, find the increase in entropy of the water if the final state is dry saturated steam. Assume for liquid water C_p = 4.2 kJ/kgK. [6+10]

4. (a) Explain : "Available energy" and "Availability" and Irreversibility.
   (b) Define Melmholtz and Gibbs free energy function. [9+7]

5. A certain quantity of mass of air is initially at 280^0 C and 8 bar, and occupies $0.035m^3$. The air is expanded at constant pressure to $0.1m^3$. A polytropic process with n=1.4 is then carried out, followed by a constant temperature process which complete a cycle. All the processes are reversible.
   (a) Sketch the cycle in a p-v and T-s planes,
   (b) find the heat received and the heat rejected in the cycle, and
   (c) find the efficiency of the cycle. [16]

6. (a) An air tank of volume $10m^3$ is at 70kPa and 100^0C. Now water is injected into the tank keeping the temperature at 80^0C. Determine the mass of water required to be injected so that the tank is just filled with saturated vapour.
   (b) If the water injection continues upto 30%more than what is required for saturated vapour calculate the total pressure in the tank. [8+8]

7. (a) Define mean effective pressure. What is its importance in reciprocating engines.
   (b) A diesel cycle operating on an air standard cycle has a compression ratio at 15. The pressure and temperature at the beginning of the compression are 1.04 bar and 15^0c. If the maximum temperature of the cycle is 2330K, determine
      i. the thermal efficiency and
      ii. The mean effective pressure. [6+10]

8. An ammonia ice plant operates between a condenser temperature of 35^0C and an evaporator temperature of -15^0C. It producers 10 tons of ice per day from water at 30^0C to ice at -5^0C. Assume simple saturation cycle. Using only tables of properties for ammonia, determine:
   (a) The capacity of the refrigeration plant
   (b) The mass flow rate of refrigerant
   (c) The discharge temperature
   (d) The compressor cylinder diameter and stroke if its volumetric efficiency is 0.65, rpm = 1200 and stroke/bore ratio = 1.2,
   (e) The horse power of the compressor motor if the adiabatic efficiency of the compressor 0.85 and mechanical efficiency 0.95 and
   (f) The theoretical and actual C.O.P. [16]

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1. (a) What do you mean by the system? Discuss types of systems with one example each.
   (b) What is the difference between heat and energy.
   (c) Explain what do you mean by thermodynamic equilibrium. [8+4+4]

2. Calculate C_P and C_v of air if 0.46 kg of air at 179^{o}C expends isentropically to three times its original volume. During this expansion process the temperature drops to 15.5^{o}C. The work done by the air is 52.9 kj. [16]

3. A heat pump is used to heat a house in winter and then reversed to cool the house in summer. The interior temperature is to be maintained at 20^0C. heat transfer through the walls and roof are estimated to be $0.525kJ/sper^0$C temperature difference between the inside and outside.
   (a) If the outside temperature is 5^0C in winter, what is the minimum power required to drive the heat pump?.
   (b) If the power output is same as in part (a) what is the maximum temperature for which the inside temperature can be maintained at 20^0C? [16]

4. (a) Explain third law of Thermodynamics.
   (b) A tank holds 1 kg of air at 100 kPa, 40^0C, and another tank holds 1 kg of air at 200 kPa, 40^0C. The atmosphere is at 100 kPa, 20^0C. In which tank is the stored energy is greater? Determine the availability of the air in each tank. [6+10]

5. (a) Following observation were recorded in a test on a combined separating and throttling calorimeter. Determine the quality of steam. For superheated steam C_{ps} = 2kJ/kg K. Pressure in the steam line = 800kPa; Pressure of the steam after throttling = 100 kPa;
   Temperature of the steam after throttling = 105^0C.
   Mass of steam collected in the separator = 0.25kg;
   Mass of the steam condensed after throttling = 2.25kg;
   (b) Find the enthalpy of vaporization of water at 100^0C using both steam table and Clausis-Clapeyron equation. [8+8]

6. (a) Methane at 150kPa, 20^0C enters an insulated mixing chamber at a rate of 1.0kg/s .It is mixed with air at 150kPa and 180^0 C in an air methane mass ratio of 15:1. The flow is steady and kinetic energy changes are negligible. Ambient pressure and temperature are 100kPa 15^0C. Determine:

i. The temperature of the mixture leaving the chamber and
ii. The irreversibility of the mixing per kg of methane.

(b) How gravimetric analysis can be compared with volumetric analysis? [10+6]

7. (a) Derive an expression for the efficiency of the ideal cycle for the diesel engine in terms of the compression ratio, the cut off ratio and adiabatic index.

(b) In a car working on Otto cycle has initial pressure 1 bar and pressure after compression 10 bar. Calculate

i. the compression ratio.
ii. The percentage clearance
iii. The thermal efficiency. [8+8]

8. Draw the line diagram of the Bell-Coleman refrigeration cycle retrigesetion. Explain with the help of a P-V diagram, different processes in the cycle. Explain its advantages and disadvantages. [16]

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