B.E. (Mech) Part-II 3rd Semester Examination, 2011.

Subject : Basic Thermodynamics (ME-301)

Branch : Mechanical . Engineering

Time: 3 Hours. Full Marks: 70

Answer six questions taking three from each half.

All questions are of equal value.

FIRST HALF

1. (a) What do you mean by thermodynamic system? How does a control volume differ from a thermodynamic system?

(b) A reversible heat engine works between three reservoirs A, B and C. The engine receives equal amount of heat from reservoir A and reservoir B at temperatures T_A and T_B respectively and rejects heat to a reservoir C at temperature T_C. If the efficiency of the engine is α times the efficiency of a reversible engine operating between two reservoirs A and C only, show that

$$\frac{T_A}{T_B} = 2(1-\alpha)\frac{T_A}{T_C} + (2\alpha - 1)$$

(c) State Kelvin-Planck statement of the second law of thermodynamics. What is PMM2?

2. (a) A system is taken from state 1 to state 2 by following two different processes, a reversible process R and an irreversible process I. Is the entropy change of the system same for both processes? Explain you answer.

(b) A perfect gas flows through a nozzle where it expands in a reversible adiabatic manner. The inlet conditions are 22 bar, 500^0C, 38 m/s and the pressure at the exit is 2 bar. Determine the exit velocity and exit area if the the flow rate is 4 kg/s. take, R (characteristic gas constant) = 190 J/kg-K and $\gamma = 1.35$ for the gas. Also use the fact that for a perfect gas: enthalpy difference = specific heat at constant pressure × temperature difference.

(c) What do you mean by exergy and anergy?

3. (a) Show that when a perfect gas changes from state (P_1,V_1,T_1) to another state (P_2,V_2, T_2), the change in entropy per unit mass is given by $S_2 - S_1 = C_v \ln\frac{P_2}{P_1} + C_p \ln\frac{V_2}{V_1}$.

(b) One kg-mol of oxygen at 350 K undergoes a reversible non-flow isothermal expansion and the volume increases from 0.06 m^3/kg to 0.15 m^3/kg. Using Vander waal's equation of state, calculate the final pressure and work done during the process. How does this value for work compare with that obtained using ideal gas equation of state? The Van der Waal's equation of state is given by

$\left(p + \frac{a}{v^2}\right)(v - b) = R_0 T$, where p is the pressure of the gas in N/m^2, v is molar volume and R_0 (= 8314 J/kg-mol K) is the universal gas constant. The constants a and b have the following values for oxygen: $a = 139.35\times10^3$ Nm^4(kg-mol)^2, $b = 0.0314$ m^3/kg-mol.

4.(a) The thermal capacity at constant volume of a thermodynamic system initially at 300 K is prescribed by the relation $C_v = AT^2$, where A = 0.042 J/K^3. A low temperature sink is available at 200 K and a heat engine is made to operate between the reservoirs. Determine the maximum amount of work that can be obtained as the system is cooled down to the temperature of the sink.

(b) Give the mathematical statement of Clausius inequality and explain its significance.

(c) Apply first law of thermodynamics to find the heat transfer in a boiler

5. Write short notes on any THREE of the following:

(i) High grade and low grade energy
(ii) Carnot cycle
(iii) Polytropic specific heat
(iv) Entropy change due to mixing of two fluids

SECOND HALF

6 (a) What do you mean by apparent gas constant and molecular weight of a mixture of perfect gasses? Explain in brief the Gibbs-Dalton law.

(b) A vessel contains a mixture of perfect gasses comprising of 25 kg of CO_2, 11 kg of O_2, and 15 kg of N_2 respectively. Total pressure of the mixture of gasses in the vessel is 250 kN/m^2 and temperature is 65^{0}c. Calculate (i) the equivalent gas constant and equivalent molecular weight, (ii) C_p and C_v of the mixture, and (iii) the partial pressure of each gas in the vessel. Assume that C_p for CO_2, N_2, and O_2 are 1.235, 1.172, and 1.088 kJ/Kg.K respectively.

7 (a) With the help of a neat labeled diagram, explain in brief the working of an Orsat apparatus. Also mention its importance in respect to application in industry.

(b) The results of the analysis of dry flue gas of a boiler by volume are noted to be 13.2% CO_2, 5.3% O_2, and 0.4% CO respectively. The analysis of coal by weight is found to be 65% C, 4% H_2, 3% O_2, 1%S, 1% N_2, 8% Moisture, and rest is Ash. Estimate (i) theoretical air-fuel ratio, (ii) % of excess air, and (iii) the quantity of dry and wet flue gases per kg of coal.

8 (a) With the help of a neat labeled schematic diagram explain in brief the working of a universal calorimeter. State its importance. Discuss how finally the dryness fraction of steam is assessed.

(b) Steam expands isentropically from 90 bar and 480^{0}C to 0.05 bar. Calculate dryness fraction, specific enthalpy, specific entropy, and specific volume of steam after the expansion. Use steam table.

9 (a) Discuss in brief about Sling Psychrometer and Psychrometric Chart. State their importance.

(b) The dry bulb and wet bulb temperatures recorded by a Sling Psycrometer are 28^{0}c and 21.5^{0}c respectively. If the atmospheric pressure is 1 bar, estimate (i) specific humidity, (ii) dew point temperature, and (iii) specific enthalpy of mixture.

10 Write short notes on any THREE of the following:

(i) Gibb's phase rule
(ii) Conversion of volumetric analysis to gravimetric analysis and gravimetric analysis to volumetric analysis
(iii) P-T and T-p diagrams of pure substance
(iv) Psychrometric processes