B. MECH ENGG. FIRST YEAR, 2ND SEMESTER EXAMINATION 2018

THERMODYNAMICS

Time: Three hours **Full Marks: 100**

Answer to all parts of a question must be together.

NB: Assume any data, if not furnished, consistent with the problem. Use of relevant tables and charts are permitted.

1. a) What do you mean by 'universe'- explain with example
   b) Define and provide examples of intensive and extensive property
   c) Discuss 'critical point' and 'dryness fraction' with proper diagrams
   d) Show the following processes for a pure substance with proper labeling:

   Isobaric process from superheated vapor zone to sub-cooled liquid zone on T-s plane.

   d) Both thermodynamic and thermal equilibrium imply the same thing – comment on this statement
   e) Define stoichiometric air-fuel ratio

   3+4+6+3+2+2 (20)

2. a) State the first law of Thermodynamics for a system undergoing a cyclic process. Prove that internal energy is a property of the system.

   Or

   Prove that no heat engine can have higher efficiency than that of a reversible heat engine for given two heat reservoirs.

   b) State four Maxwell relations and hence derive the Clapeyron equation.

   Or

   Derive an expression for Joule Thompson coefficient.

   8+12 (20)

---

3. Answer any three (3) questions out of four in this group

a) Air is compressed in a quasi-equilibrium process from 80 kPa, $0.1m^3/kg$ to 0.4MPa and $0.03m^3/kg$. Assuming that the process is described by polytropic process pv^n=constant, find work done on the gas and the heat transfer. Assume c_v=0.718kJ/kgK, R=0.287kJ/kgK.

b) Two Carnot engines A and B are operating in series. A rejecting heat directly to B. Engine A receives 200 kJ at a temperature of 421^0 C. Engine B rejects heat at temperature 4.4^0 C. If the work output of A is twice that of B, find i) intermediate temperature between A and B , ii) efficiency of each engine, iii) heat rejected to the cold sink.

c) A vessel of volume 0.04 m^3 contains a mixture of saturated water and saturated steam at a temperature of 250^0C. The mass of liquid present is 9kg. Find the pressure, mass, specific volume, specific enthalpy, and specific entropy of the mixture.

d) Calculate the stoichiometric air-fuel ratio of the combustion of coal of following composition by mass: C 90%, H_2 3%, O_2 2.5%, N_2 1%, S 0.5%, Ash 3%.

10 x 3 (30)

4. a) In the turbine of a gas turbine unit, the gas flows through the turbine at 17 kg/s and the power developed by the turbine is 14 MW. The specific enthalpies of the gas at inlet and outlet are 1200 kJ/ kg and 360 kJ/ kg respectively with corresponding velocities at 60m/s and 120 m/s. Calculate the rate at which heat transfer takes place from the turbine, Find out the diameter of the inlet pipe if the specific volume at inlet is 0.5 m^3/ kg.

b) A piston–cylinder contains 1.0 kg of water at 20^0 C with a volume of 0.1 m^3. Initially the piston rests on the stops with the top surface open to atmosphere so that a pressure of 300 kPa is required to lift it. To what temperature should the water be heated to lift the piston? If it is further heated to saturated vapor find the final temperature, volume and the total heat and work transfer.

c) Air flows steadily through an air compressor, entering at 6 m/s velocity, 100 kPa pressure and 17^0 C, through an inlet area of 0.1 m^2 , and leaving at 2 m/s, 700 kPa, and temperature of 177^0 C. Heat transfer rate from the compressor to the surroundings is 180 kJ/ minute. Calculate the power required to drive the compressor.

10+12+8 (30)