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VASAVI COLLEGE OF ENGINEERING *(Autonomous)*, HYDERABAD

B.E. (Mech. Engg.: CBCS) III-Semester Main Examinations, December-2017

Thermodynamics

Time: 3 hours Max. Marks: 70

Note: Answer ALL questions in Part-A and any FIVE from Part-B

Part-A (10 × 2 = 20 Marks)

1. What is the least possible temperature for the water to be in the liquid state? What happens if a system goes below to that value?
2. In thermodynamic point of view, how Kelvin scale is different from centigrade scale?
3. Explain the corollaries of first law of thermodynamics.
4. What is PMM1? Why is it impossible?
5. A reversible process adds heat to a substance. If Temperature (T) is varying, how does that influence the change in entropy (s)?
6. State Carnot theorem and its corollaries?
7. What is meant by 'pure substance'?
8. Draw the phase diagram of a substance (which won't expand upon freezing) on P-T coordinates.
9. State Dalton's law.
10. Write the expressions for Thermal efficiency of Diesel and Dual cycles.

Part-B (5 × 10 = 50 Marks)

11. a) Consider an automobile travelling at a constant speed along a road. Determine the direction of heat and work interactions, taking the following as the system: [5]
    i) The car radiator
    ii) The car engine
    iii) The car wheels
    iv) The road
    v) The air surrounding the car.

    b) A new scale of temperature is divided in such a way that the freezing point of ice is 100^0N and the boiling point is 400^0N. What is the temperature reading on this new scale when the temperature is 150^0c? Estimate the temperature at which both the Celsius and the new temperature scale readings would be the same. [5]

12. a) A gas of mass 1.5 kg undergoes a quasi-static expansion which follows a relationship $p = a + bV$, where a and b are constants. The initial and final pressures are 1000 kPa and 200 kPa respectively and the corresponding volumes are 0.20 m^3 and 1.20 m^3. The specific internal energy of the gas is given by the relation $u = 1.5\ pv - 85$ kJ/kg where p is the kPa and v is in m^3/kg. Determine the net heat transfer and the maximum internal energy of the gas attained during expansion. [6]

    b) A turbo compressor delivers 2.33 m^3/s at 0.276 MPa, 43°C which is heated at this Pressure to 430°C and finally expanded in a turbine which delivers 1860 kW. During the expansion, there is a heat transfer of 0.09 MJ/s to the surroundings. Determine the turbine exhaust temperature if changes in kinetic and potential energy are negligible. [4]

Contd... 2

13. a) A heat engine is used to drive a heat pump. The heat transfers from the heat engine and from the heat pump are used to heat the water circulating through the radiators of a building. The efficiency of the heat engine is 27% and the COP of the heat pump is 4. Evaluate the ratio of the heat transfer to the circulating water to the heat transfer to the heat engine. [5]

    b) Write the Kelvin-Planck and Clausius statements of the second law of thermodynamics and prove their equivalence. [5]

14. a) A rigid container has 0.75 kg water at 300^0C, 1200 kPa. The water is now cooled to a final pressure of 300 kPa. Find the final temperature, the work and the heat transfer in the process. [4]

    b) Develop Maxwell's relations. [6]

15. a) An engine working on an Otto cycle has an air standard efficiency of 50% and rejects 544 kJ/kg of air. The pressure and temperature of air at the beginning of the compression are 0.1 MPa and 60^0c respectively. Determine (i) the compression ratio of the engine, (ii) work done per kg of air, (iii) the pressure at the end of compression, (iv) the temperature at the end of compression, (v) maximum pressure in the cycle. [5]

    b) Develop an expression for the efficiency, work done and mean effective pressure of Dual cycle in terms of pressure ratio (k), compression ratio (r) and cut off ratio (ρ). [5]

16. a) Can we apply classical thermodynamics principles for systems which are at very high vacuum? Support your answer. [4]

    b) A nozzle is a device for increasing the velocity of a steadily flowing stream. At the inlet to a certain nozzle, the enthalpy of the fluid passing is 3000 kJ/kg and the velocity is 60 m/s. At the discharge end, the enthalpy is 2762 kJ/kg. The nozzle is horizontal and there is negligible heat loss from it. [6]
    i) Find the velocity at exit from the nozzle.
    ii) If the inlet area is 0.1 m^2 and the specific volume at inlet is 0.187 m^3/kg, find the mass flow rate.
    iii) If the specific volume at the nozzle exit is 0.498 m^3/kg, find the exit area of the nozzle.

17. Answer any *two* of the following:

    a) A closed system contains air at a pressure of 1 bar, temperature 27^0C and volume $0.018 m^3$. This system undergoes a thermodynamic cycle consisting of the following three processes in series: [5]
    i) Constant volume heat addition till pressure becomes 0.5MPa,
    ii) constant pressure cooling and
    iii) isothermal heating to complete the cycle. Represent the cycle on T-s and p-V plots and evaluate the change in entropy for each process.

    b) Why do the isobars on Mollier diagram diverge from one another? Explain with a neat sketch. [5]

    c) Represent Rankine cycle on P-v and T-s coordinates. Develop an expression for its thermal efficiency. [5]

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