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# MANIPAL INSTITUTE OF TECHNOLOGY
MANIPAL
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## III SEMESTER B. TECH (MECHANICAL ENGG.) END SEMESTER EXAMINATIONS, NOVEMBER 2018

## SUBJECT: THERMODYNAMICS - I [MME 2101]

**REVISED CREDIT SYSTEM**

Time: 3 Hours MAX. MARKS: 50

**Instructions to Candidates:**

- Answer **ALL** the questions.
- Missing data may be suitably assumed.
- Use of Thermodynamics data hand book is permitted

**1A.** Define (i) Process (ii) Property (iii) System Boundary (iv) Enthalpy **2**

**1B.** Define heat and work.
What are the similarities and difference between heat and work? **3**

**1C.** A 260 mm diameter cylinder fitted with a frictionless leak proof piston contains 0.02 kg of steam at a pressure of 6 x $10^5$ N/$m^2$ and a temperature of $200^0$C. As the piston moves slowly outwards through a distance of 305 mm the steam undergoes a fully resisted expansion according to the law $PV^n$ = a constant to a final pressure 1 bar. Determine: (i) value of the index n (ii) work done by the steam. Assume that steam at the given condition behaves as an ideal gas. **5**

**2A.** State the first law of thermodynamics applied to (i) A Closed system undergoing change of state (ii) A closed system undergoing thermodynamic cycle. **2**

**2B.** Prove that two statements of second law of thermodynamics are equivalent statements. **3**

**2C.** Air enters at $15^0$C through a heat exchanger at a velocity of 30m/s where its temperature is raised to $800^0$C.It then enters a turbine with the same velocity of 30m/s and expands until the temperature falls to $650^0$C.Air leaves the turbine at 60m/s to a nozzle where it expands until the temperature is $500^0$C.If the air flow rate is 2kg/s, calculate (a) Rate of heat transfer to the air in the heat exchanger (b) power output of the turbine, assuming heat loss (c) velocity of air at the exit of the nozzle assuming no heat loss in the nozzle. Assume that specific enthalpy:$h = Cp\, t \text{ where } Cp = 1.005 kJ/kgK \text{ and } t \text{ is the temperature in centigrade}$ . **5**

**3A.** Define entropy and show that it is a property of the system. **2**

**3B.** With usual notations write the SFEE and clearly mention the units of each term in equation. Reduce the SFEE for the following cases under ideal condition: (i) A Centrifugal compressor (ii) Steam Boiler. **3**

**3C.** Two reversible heat engines are working in series. The reversible heat engine 'M' takes heat from a reservoir at $1000^0$C and rejects heat to reversible heat engine 'N' which rejects heat to the sink maintained at $0^0$C. Determine the intermediate temperature and percentage work contribution of two heat engines for the equal efficiency. **5**

**4A.** Obtain an expression for entropy change of an ideal gas in terms of specific heat at constant volume, temperature ratio and gas constant. **2**

**4B.** A mass of 1.5 k-mole of an ideal gas of molecular mass 25 is contained in a rigid vessel of volume 4 $m^3$ at a temperature of $100^o$ C. Evaluate the mass, the pressure, the specific volume and the gas constant of the gas. If the value of $\gamma$ = 1.38. (i) Evaluate the corresponding values of $C_P$, $C_V$. (ii) Subsequently the gas cooled to atmospheric temperature $15^o$ C. Evaluate the final pressure of the gas. (iii) Assuming the gas to be perfect, evaluate the increase in internal energy, the increase in enthalpy, change in entropy and the magnitude and sign of the heat transfer. **4**

**4C.** A rigid vessel containing 0.1 $m^3$ of CO at a temperature of $15^o$C and a pressure of 60kPa, is connected via a valve and a short pipe, to a second rigid vessel containing 0.15 $m^3$ hydrogen at a temperature of $15^o$ C and a pressure of 160kPa. The vessels, the valve and the pipeline are well insulated. The valve, initially shut, is opened to allow the two gases to mix; after a time, conditions become uniform throughout the vessels. Assuming CO and $H_2$ to be perfect gases and taking the $C_P$ =1.042kJ/kg-K for CO $C_P$ =14.310 kJ/kg-K for $H_2$, evaluate: (i) Partial pressure of the components. (ii) Specific volume of the mixture (iii) Gas constant, specific heats and $\gamma$ of the mixture (iv) Increase in entropy. **4**

**5A.** Define: (i) Mole fraction (ii) Mass fraction (iii) Partial pressure (iv) Compressibility factor **2**

**5B.** Write the phase equilibrium diagram (P-T diagram) for the pure substance and locate all the phases and phase boundaries. **3**

**5C.** A spherical rigid vessel of 0.9$m^3$ capacity contains steam at 8bar and 0.9dry. Steam is blown off until the pressure drops to 4 bar. The valve is closed and the steam is allowed to cool until the pressure falls to 3bar. Assuming that enthalpy of steam in the vessel remains constant during blowing off periods, determine (i) The mass of steam blown off (ii) Heat lost during the cooling process. **5**