**BIRLA INSTITUTE OF TECHNOLOGY AND SCIENCE, PILANI**
**SECOND SEMESTER, 2013 – 2014, DATE: 11/05/2014**
**COMPREHENSIVE EXAMINATION (CLOSED BOOK)**

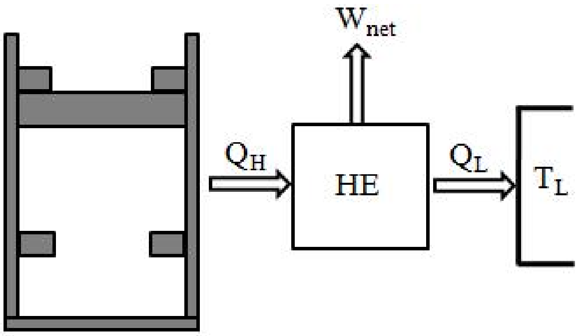
Course No: BITSF111 Time: 120 min.
Course Title: THERMODYNAMICS Max. Marks: 95

**SUBJECTIVE**

- **It consists of Part-A and Part-B**
- **Answer PART-A and PART-B question in respective answer book.**
- **Underline the final answers and assume suitable data wherever necessary**

## PART –A

Q.1. Consider the piston/cylinder arrangement shown in Figure. The piston is free to move between two set of stops. When the piston touches the upper stops, the enclosed volume is 4000 L. When the piston rests on the lower stops, the volume is 1000 L. The cylinder initially contains water at 2 MPa and 1000°C. The piston is loaded with a mass and outside atmosphere such that it floats when the pressure is 600 kPa. The setup is now cooled to 100°C by giving heat to a reversible heat engine that has its cold side at ambient 27°C. Neglect the thickness of piston and stops. If the overall process is reversible, determine (a) the heat transfer from the water to heat engine (b) the heat rejected to the ambient (c) the net work output of the heat engine d) the thermal efficiency of heat engine e) reversible work and second law efficiency of overall system **[16]**




Q.2 Steam enters a turbine operating at steady state at a pressure of 3 MPa, a temperature of 400$^0$C and velocity 160 m/s. Saturated vapour exits at 100 kPa with a velocity of 100 m/s. Heat transfer from the turbine to its surrounding takes place at the rate of 30 kJ/ kg of steam at the location where average surface temperature is 350 K. The steam turbine located in the factory where ambient temperature is 300K. Calculate (a) actual work output (b) isentropic efficiency (c) reversible work output (d) irreversibility (e) entropy generation (f) second law efficiency

**[18]**

Q.3. An insulated constant pressure piston-cylinder assembly with mass-less and frictionless piston. The system is initially filled with 200 L of water at 20°C. Saturated steam is supplied to the cylinder from a pipe line at 1 kg/min, 300 kPa. The steam flow is cut off when the water reaches a homogeneous temperature of 70°C. Given that the ambient pressure is 100 kPa, determine the a) time required to heat the water to 70°C b) total mass of the water within the cylinder when it reaches 70°C c) find the entropy generation during the process, and d) steam flow rate for which the water within the cylinder becomes saturated liquid in 25 min. **[15]**

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## PART –B

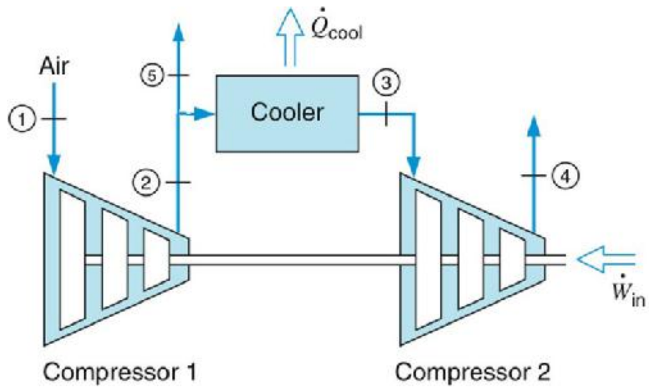
Q.4 Rigid tank of Volume 0.4 $m^3$ is filled with steam from a supply line (1.4 MPa, Temperature=300$^0$C ). The heat loss is to be estimated from experimental measurements (only pressure and temperature). Starting from the first law for a C.V.(neglect Kinetic energy and Potential Energy terms)

$$\underbrace{\dot{Q}_{C.V.}}_{} - \dot{W}_{C.V.} = \dot{m}_e h_e - \underbrace{\dot{m}_i h_i}_{} + \underbrace{[\text{illegible}]}_{}$$

Term 1 Term 2 Term 3

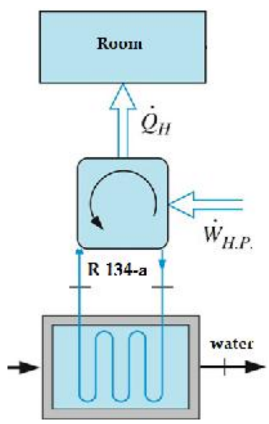
a) integrate term 1, 2 and 3 respectively b) state assumptions clearly (if any) in one line **against each** integration c) Determine the heat loss, if possible for i) tank initially evacuated and final conditions are measured as 1.4 MPa and 200$^0$C ii) tank initially measured as 350 kPa and 138.88$^0$C and final condition 1.4 MPa and 195.07$^0$C. **[10]**

Q.5 In two-stage insulated compressor as shown in fig., compressor-1 receives 10 kg of air per min at surrounding condition of 100 kPa, 30 $^0$C. The exit of the compressor-1 is at 150kPa. At this point 25% (on mass basis) of the air is taken out and the remaining air is passed through an intercooler where the air is cooled by 40$^0$C and then compressed to 250 kPa in the compressor-2. The isentropic efficiency of the both the compressors is 85 %. Assuming constant specific heats, determine




a) temperature at the exit of each compressor b) change in rate of exergy of the air in the compressor-1 c) change in rate of exergy of the air in compressor-2 d) the irreversibility rate of compressor-1 and compressor-2 **[20]**

Q.6 A heat pump with R-134a as the working fluid is used to keep a room at 25 $^0$C by absorbing heat from processed water in an evaporator. Water enters the evaporator at 100 kPa and 50 $^0$C at the rate of 0.065 kg/s and leaves at 40 $^0$C and same pressure. Refrigerant enters the evaporator at 20 $^0$C with a quality of 15% and leaves at the same pressure as saturated vapor. Assume the ambient temperature is 15 $^0$C. If the work input to the heat pump is 1.2 kW, determine a) mass flow rate of R-134a b) rate of heat supplied to the room c) COP of the heat pump d) entropy generation during the process f) irreversibility rate **[16]**




******** HAPPY MOTHER'S DAY ********