B. CHEMICAL ENGINEERING 2ND YEAR 1ST SEMESTER EXAMINATION, 2017

ENGINEERING THERMODYNAMICS

Time: 3 Hours Full Marks: 100

Attempt any *five* questions
Steam and other tables may be used
Assume any data, if required

1. (a) State the zeroth law of thermodynamics. Explain how empirical temperature is conceived from this law. (10)

   (b) A 1 m^3 rigid tank with air at 1 Mpa, 400 K is connected to an air line as shown in Figure Q1(b). The valve is opened and air flows into the tank until the pressure reaches 5 Mpa, at which point the valve is closed and the temperature inside is 450 K. What is the mass of air before and after the process? The tank eventually cools to room temperature, 300 K. What is the pressure inside the tank then? (10)

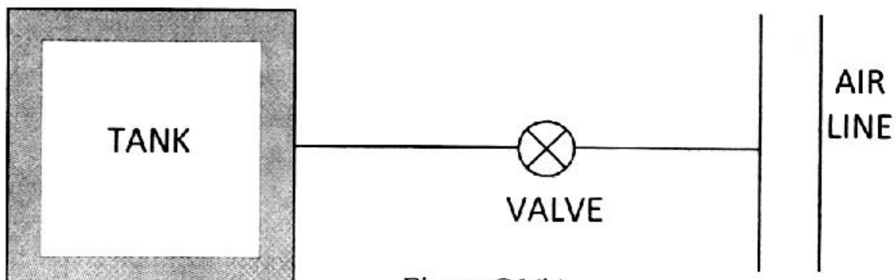

Figure Q1(b)

2. (a) State the First Law of Thermodynamics for a system executing a process. Hence show that enthalpy and the specific heats at constant pressure and volume are properties. (10)

   (b) When a system is taken from state *a* to state *b*, in Figure Q.2(b) along path *acb*, 84 kJ of heat flow into the system, and the system does 32 kJ of work. (i) How much will the heat that flows into the system along path *adb* be, if the work done is 10.5 kJ? (ii) When the system is returned from *b* to *a* along the curved path, the work done on the system is 21 kJ. Does the system absorb or liberate heat, and how much is the heat absorbed or liberated? (iii) If $U_a = 0$ and $U_d = 42$ kJ, find the heat absorbed in the processes *ad* and *db*. (10)

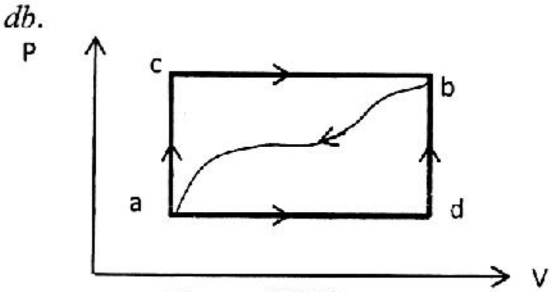

Figure Q 2(b)

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3. (a) Show that of all refrigerators working between the same two temperature reservoirs, the COP of a reversible refrigerator is the maximum. (10)

   (b) A heat engine receives half of its heat supply at 1000 K and half at 500 K while rejecting heat to a sink at 300 K. What is the maximum thermal efficiency of the heat engine? (10)

4. (a) Derive the energy balance equation for a control volume executing a steady state steady flow process. (10)

   (b) Two flow-streams of water, one at 0.6 Mpa, saturated vapour, and the other at 0.6 Mpa, 600°C, mix adiabatically in an SSSF process to produce a single flow out at 0.6 Mpa, 400°C. Find the total entropy generation for this process. (10)

5. (a) Discuss i) Useful work, ii) Dead state and iii) Flow exergy (3+3+4=10)

   (b) Steam enters a turbine steadily at 3 Mpa and 450°C at a rate of 8 kg/s and exits at 0.2 Mpa and 150°C. The steam is losing heat to the surrounding air at 100 kPa and 25°C at the rate of 300 kW, and the kinetic and potential energy changes are negligible. Determine (a) the actual power output, (b) the maximum possible power output (the reversible power), (c) the second law efficiency. Plot the process on h-s plane. (10)

6. (a) Plot an Air Standard Diesel cycle on *PV* and *TS* planes. Derive an expression for the efficiency of Diesel cycle in terms of appropriate dimensionless parameters. (10)

   (b) At the beginning of compression in an air standard Otto cycle, $t = 50^0$C, $P_1 = 100$ kPa and $V_1 = 0.2\ m^3$. If the compression ratio is 6 and the maximum cycle temperature is 1400^0C, calculate i) the heat added, ii) the heat rejected, iii) the net work done, and iv) the efficiency. (10)

   (c) Write short notes on any *four* of the following: (5x4=20)

   (a) Quasistatic process
   (b) Carnot cycle
   (c) Rankine cycle
   (d) Clausius-Clapeyron equation
   (e) Principle of increase of entropy