B.E. CHEMICAL ENGINEERING SECOND YEAR FIRST SEMESTER EXAM 2018

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) Discuss i) Thermodynamic equilibrium, ii) Quasistatic Process (08)

(b) A piston-cylinder arrangement as shown in Figure Q 1(b), contains air at 250 kPa, 300°C. The 50 kg piston has a diameter of 0.1 m and initially pushes against the stops. The atmosphere is at 100 kPa and 20°C. The cylinder now cools as heat is transferred to the ambient.

i. At what temperature does the piston begin to move down?
ii. How far the piston dropped when the temperature reaches ambient?
iii. Draw the process on P-V plane. (12)

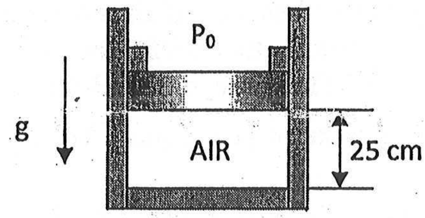

Figure Q 1(b)

2. (a) State the first law of thermodynamics for a system undergoing a cycle. Also state the first law of thermodynamics for a system undergoing a process. Discuss about the Perpetual Motion Machine of the first kind. (08)

(b) A frictionless piston-cylinder device initially contains 200 L of saturated liquid refrigerant-134a. The piston is free to move, and its mass is such that it maintains a pressure of 800 kPa on the refrigerant. The refrigerant is now heated until its temperature rises to 50°C. Calculate the work done and heat transfer during this process. Plot the process on P-v plane. (12)

3. (a) Write the Kelvin-Planck statement and Clausius statement of the second law of thermodynamics. Hence prove that the violation of the Kelvin-Planck statement leads to the violation of the Clausius statement. (10)

(b) An inventor claims to have developed a refrigeration unit which maintains the refrigerated space at –10°C while operating in a room where the temperature is 25°C, and which has a COP of 8.5. How do you evaluate his claim? How would you evaluate his claim of a COP of 7.5? (10)

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4. (a) Define exergy. Derive the expression of exergy of a system at a given state inside a given environment. (10)

   (b) Steam enters a turbine at 3 MPa, 450°C, expands in a reversible adiabatic process and exhausts at 10 kPa. Changes in kinetic and potential energies between the inlet and exit of the turbine are small. The power output of the turbine is 800 kW. What is the mass flow rate of steam through the turbine? Plot the process on h-s plane. (10)

5. (a) Derive the Clapeyron equation to correlate subcritical temperature of a pure substance with corresponding saturation pressure. (08)

   (b) A piston cylinder device contains 0.05 kg of steam at 1 Mpa and 300°C. The steam now expands to a final state of 200 kPa and 150°C, doing work. Heat losses form the system to the surroundings are estimated to be 2 kJ during this process. Assuming the surroundings to be at $T_0 = 25°C$ and $P_0 = 100$ kPa, determine (i) the exergy of the steam at the initial and final states, (ii) the exergy change of the steam, and (iii) the second law efficiency of the process. (12)

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

   (b) Consider an ideal refrigeration cycle that has a condenser temperature of 45°C and an evaporator temperature of -15°C. Determine the coefficient of performance of this refrigerator for the working fluids R-134a. Plot the cycle on P-h plane. (10)

7. (a) Draw the schematic diagram of a simple steam power plant. Hence plot the corresponding Rankine cycle on T-s plane. (05)

   (b) A steam power plant has a boiler exit at 4 MPa, 500°C and a condenser exit temperature of 45°C. Assume all components to be ideal. Find the cycle efficiency and the specific work and heat transfer in the components. Plot the cycle on h-s plane. (15)

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

   (a) Ideal gas temperature scale
   (b) Carnot cycle
   (c) Throttling process
   (d) PMM II
   (e) Reversible process