King Saud University
Mechanical Engineering Department
Final ME-371 Thermodynamics I,
Thermodynamics Property tables are allowed,
Three hours exam, 19-2-1431 H

Question 1

a- Draw Otto cycle on the P-v and T-S diagrams and prove that its thermal efficiency is given by:

$$\eta = 1 - \frac{1}{r^{k-1}}$$

Where r is the compression ratio and k is the specific heat ratio.

b- The initial condition for an air-standard Otto cycle operating with a compression ratio of 8 are 0.95 bar and 17^{o}C. At the beginning of the compression stroke, the cylinder volume is 220 L, and 3.6 kJ of heat is added during the constant volume heating process. Calculate the pressure and temperature at the end of each process of the cycle, and determine the thermal efficiency and the mean effective pressure of the cycle. Draw the P-v and T-S diagrams of the cycle showing and label all points of the cycle.

Question 2

a- Draw the Carnot cycle on the P-v and T-S diagrams and prove that its efficiency is give by:

$$\eta = 1 - \frac{T_L}{T_H}$$

Where T_L and T_H are the sink and source temperatures respectively.

b- The pressure, volume, and temperature in a Carnot heat engine using air as the working medium are, at the beginning of the isothermal expansion, 5 bars, 550 cm^3, and 260^{o}C, respectively. During the isothermal expansion, 0.30 kJ of heat is added, and the maximum volume for the cycle is 5300 cm^3. Determine (a) the volume after isothermal expansion, (b) the sink temperature, in degree Celsius, (c) the volume after isothermal compression, in cubic centimetres, (d) the heat rejected per cycle, (e) the thermal efficiency of the cycle, and (f) draw the P-v and T-S diagrams showing and label all points.

Question 3

a- Write down the 1st law of thermodynamics for an open system and define each term and its unit.

b- Compute the thermal efficiency of an ideal Rankine cycle for which steam leaves the boiler as saturated vapour at 3.0 MPa and is condensed at 0.1 MPa. Draw a schematic of the cycle and the T-S diagram of the cycle. Do not neglect the pump work.

Question 4

a- Draw the 1st law of thermodynamics for a complete cycle.

b- Define the following: Extensive property and intensive property, give two examples for each.

c- A piston-cylinder device contains 23 g of saturated water vapour that is maintained at a constant pressure of 300 kPa. A resistance heater within the cylinder is turned on and passes a current of 0.2 A for 5 min from a 120 V source. At the same time, a heat loss of 3.7 kJ occurs. (a) Determine the final temperature of the steam and (b) draw the P-v diagram for the process.

Question # 5

A 1-m^3 rigid tank containing air at 25°C and 500 kPa (Tank A) is connected through a valve to another tank containing 5 kg of air at 35°C and 200 kPa (Tank B). Now the valve is opened and the system is allowed to reach thermal equilibrium with the surroundings, which are at 20°C. For air as an ideal gas, determine:

a- The volume of tank B

b- The mass of air contained in tank A

c- The final equilibrium pressure of air.