UNIVERSITY OF PETROLEUM AND ENERGY STUDIES

End Semester Examination, December 2017

Program: B.Tech. (APE – Up, GSE, GIE, ET+LLB) **Semester – III**
Subject (Course): Thermodynamics and Heat Engines **Max. Marks : 100**
Course Code : GNEG241 **Duration : 3 Hrs**
No. of page/s: 2

Note: Attempt all the questions of a section <u>at one place</u>. All questions are compulsory. State your assumptions clearly.

<u>Section – A (4 x 5 = 20 Marks)</u>

1. Justify why the energy of an isolated system always remain constant.

2. Prove how a perpetual motion machine of second kind (PMM2) violates the Clausius' statement of II law of thermodynamics.

3. State Clausius' theorem and write a short notes on Clausius' inequality.

4. What is the significance of the van der Waals coefficients in van der Waals equation of state?

<u>Section – B (5 x 8 = 40 Marks)</u>

5. 0.5 kg of air is compressed reversibly and adiabatically from 80 kPa, 60^0C to 0.4 MPa and is then expanded at constant pressure to the original volume. Sketch these processes on p-v and T-s planes. Compute the heat transfer and work transfer for the whole path (γ for air = 1.4).

6. A pressure cylinder of volume V contains air at pressure p_0 and temperature T_0. It is to be filled from a compressed air line maintained at constant pressure p_1 and temperature T_1. Derive an expression for the temperature of the air in the cylinder after it has been charged to the pressure of the line.

7. Two reversible heat engines A and B are arranged in series, A rejecting heat directly to B. Engine A receives 200 kJ at a temperature of 421^0C from a heat source, while engine B is in communication with a cold sink at a temperature of 4.4^0C. If the work output is twice that of B, find (a) the intermediate temperature between A and B, (b) the efficiency of each engine and (c) heat rejected to cold sink.

8. 2 kg of water at 80^0C is mixed adiabatically with 3 kg of water at 30^0C in a constant pressure process of 1 atmosphere. Find the increase in entropy of the total mass of water due to the mixing process.

9. Estimate the critical pressure, critical volume and critical temperature of a gas in terms of given parameters (a, b and R) for the Berthelot equation of state, $p=\frac{RT}{v-b}-\frac{a}{T v^2}$

<u>Section – C (2 x 20 = 40 Marks)</u>

10. Two streams of steam, one at 2 MPa, 300^0C and the other at 2 MPa, 400^0C mix in a steady flow adiabatic process. The rates of flow of the two streams are 3 kg/min and 2 kg/min respectively. Evaluate the final temperature of the emerging stream. What would be the rate of increase in the entropy of the universe? This stream with a negligible velocity now expands adiabatically in a nozzle to a pressure of 1 kPa. Determine the exit velocity of the stream and the exit area of the nozzle.

11. In an air standard Diesel cycle, the compression ratio is 16. Compression begins at 0.1 MPa, 15^0C. Heat is added until the temperature at the end of the constant pressure process is 1480^0C. Find (a) the pressure and temperature at cardinal points of the cycle (b) the heat supplied per kg of air, (c) the cycle efficiency, (d) the cut-off ratio and (e) the mean effective pressure of the cycle.

Or

Obtain an expression for the specific work done by an engine working on the Otto cycle in terms of the maximum and minimum temperatures of the cycle, the compression ratio and constants of the working fluid (assumed to be an ideal gas). Also for what value of the compression ratio do we get maximum specific work output (if T_{min} = 300 K, T_{max} = 1600 K and C_p/C_v = 1.4?