**Ref. No. : Ex/ME/T/126/2017 (Old)**

**B.E. MECHANICAL ENGINEERING FIRST YEAR SECOND SEMESTER (Old) – 2017**

**Subject : THERMODYNAMICS-I**

Time: Three hours — Full Marks: 100

Answer any **five** questions
Use of thermodynamic tables and charts is permitted
Assume any suitable data if necessary
All parts of the same question must be answered together

1. a) State and explain the zeroth law of thermodynamics in brief. 05

b) State the similarities and differences between heat and work. 05

c) A closed system of a gas of 5kg mass undergoes expansion process ($pv^{1.3}$=constant) from 1Mpa and 0.5$m^3$ to 0.5Mpa. The specific internal energy of the gas is given by, u=1.8pv + 85 kJ/kg, where p in kPa, v in $m^3$/kg. Determine heat and work interactions and change in internal energy. 10

2. a) A gas undergoes a thermodynamic cycle consisting of the following processes:
Process 1-2: constant pressure, $p_1$=1.4 bar, $V_1$=0.028$m^3$, $W_{1-2}$=10.5kJ.
Process 2-3: compression with pv=constant, $U_3$=$U_2$.
Process 3-1: constant volume, $U_1$-$U_3$= -26.4kJ.
There are no changes in kinetic and potential energies. a) sketch the cycle on the p-v diagram. b) calculate the net work of the cycle in kJ. c) calculate the heat transfer for process 1-2 in kJ. 12

b) A compressor receives air at 100kPa, 25$^0$C and discharges that at 185$^0$C, 400kPa. The velocity of air at the inlet and exit are 150m/s and 50m/s respectively. The power input to the compressor is 3000kW. Neglecting heat transfer from the compressor and change in potential energy, find out the mass flow rate through the compressor. Assume $c_p$=1.005kJ/kgK. 08

3. a) Prove that the 'stored energy' is a property of a closed system. 08

b) Define and explain dryness fraction of steam. 04

c) A vessel having a volume of 0.4$m^3$ contains 2.0kg of liquid water and water vapor mixture in equilibrium at a pressure of 600kPa. Calculate the mass and volume of both liquid and vapor. 08

4. a) State the Kelvin-Planck and Clausius' statements of the second law of thermodynamics. Show that the violation of Kelvin-Planck statement leads to the violation of the Clausius' statement. 10

[ Turn over

4 b) A reversible heat engine operates between three heat reservoirs A, B and C. The heat received by the engine from each of the reservoirs A and B is same and at temperatures $T_A$ and $T_B$ respectively; and the engine rejects heat to the reservoir C at temperature $T_C$. If the engine efficiency is K times the efficiency of a reversible heat engine operating between two reservoirs A and C only, show that:

$$\frac{T_A}{T_B} = 2(1-K)\frac{T_A}{T_C} + (2K-1)$$ 10

5. a) Derive the expression of the air standard efficiency of an Otto cycle as a function of compression ratio. 08

b) An air standard diesel cycle has a compression ratio of 18 and the heat transferred to the working fluid per cycle is 1800kJ/kg. At the beginning of the compression process the pressure is 0.1 MPa and the temperature is $15^0$C. Determine: i) the pressure and temperature at each cardinal point in the cycle. ii) thermal efficiency and iii) the mean effective pressure. 12

6. a) Why Carnot cycle is not used in steam power plants as an ideal cycle 06

b) Show the schematic of a Rankine cycle with each of the components and the direction of steam flow. Show the cycle on T-s and h-s diagrams. 06

c) In a thermal power plant, employing ideal Rankine cycle, superheated steam at 20 bar and $400^0$C is produced in the boiler and the condenser is operated at 0.2bar. Calculate the quality of steam at the turbine outlet and the thermal efficiency. 08

7. Write short notes on the following: 05x4=20

a) Reversible process b) Assumptions of air standard cycles c) polytropic specific heat d) throttling process