(b) (i) How do you minimize the energy consumed by your domestic refrigerator? (7)

(ii) The interior lighting of refrigerators is provided by incandescent lamps whose switches are actuated by the opening of the refrigerator door. Consider a refrigerator whose 40-W lightbulb remains on continuously as a result of a malfunction of the switch. If the refrigerator has a coefficient of performance of 1.3 and the cost of electricity is Rs. 5 per kWh, determine the increase in the energy consumption of the refrigerator and its cost per year if the switch is not fixed. Assume the refrigerator is opened 20 times a day for an avenge of 30 s. (8)

Reg. No. : | | | | | | | | | | | | |

Question Paper Code : 53300

B.E./B.Tech. DEGREE EXAMINATIONS, APRIL/MAY 2019.

Third Semester

Mechanical Engineering

ME 6301 — ENGINEERING THERMODYNAMICS

(Common to Automobile Engineering, Mechanical and Automation Engineering)

(Regulation 2013)

(Also common to PTME 6301 — Engineering Thermodynamics for B.E. Part-Time — Second Semester – Mechanical Engineering — Regulation 2014)

Time : Three hours Maximum : 100 marks

(Use of approved Thermodynamics Tables, Mollier diagram, Psychrometric chart and refrigerant property tables permitted in the Examinations)

Answer ALL questions.

PART A — (10 × 2 = 20 marks)

1. Should the automobile radiator be analyzed as a closed system or as an open system?
2. What are intensive and extensive properties?
3. A reversible heat engine operates between a source at 800°C and a sink at 30°C. What is the least rate of heat rejection per kW network output of the engine?
4. Define irreversibility.
5. What are compressed solid and compressed liquid?
6. List the methods for improving the performance of the Rankine cycle?
7. What is Joule-Thomson coefficient? Why is it zero for an ideal gas?
8. What is the law of corresponding states?
9. State Amagat's law.
10. What do you meant by evaporative cooling and adiabatic mixing?

PART B — (5 × 13 = 65 marks)

11. (a) A gas occupies 0.3 m^3 at 2 bar. It executes a cycle consisting of processes:

(i) 1 - 2, constant pressure with work interaction of 15 kJ

(ii) 2 - 3, compression process which follows the law $pV = C$ and $U_3 = U_2$ and

(iii) 3 - 1, constant volume process, and reduction in internal energy is 40 kJ

Neglecting the changes in Kinetic energy and Potential energy, draw pV diagram for the process and determine net work transfer for the cycle. Also show that first law is obeyed by the cycle.

Or

(b) In a gas turbine, the gases enter the turbine at the rate of 5 kg/s with a velocity of 50 m/s and the enthalpy of 900 kJ/kg and leaves the turbine with 150 m/s and the enthalpy of 400 kJ/kg. The loss of heat from the gas to the surroundings is 25 kJ/kg. Assume R = 0.285 kJ/kg K, Cp = 1.004 kJ/kg K and the inlet conditions to be at 100 kPa and 27°C. Determine the work done and diameter of the inlet pipe.

12. (a) One kmol of methane is stored in a rigid vessel of volume 0.6 m^3 at 20°C. Determine the pressure developed by the gas by making use of the compressibility chart.

Or

(b) Derive the entropy equations.

13. (a) A large insulated vessel is divided into two chambers, one containing 5 kg of dry saturated steam at 0.2 MPa and the other 10 kg of steam, 0.8 quality at 0.5 MPa. If the partition between the chambers is removed and the steam is mixed thoroughly and allowed to settle, find the final pressure, steam quality and entropy change in the process.

Or

(b) (i) Why is Carnot cycle not practicable for a steam power plant? (5)

(ii) In a steam power plant the condition of steam at inlet to the steam turbine is 20 bar and 300 °C and the condenser pressure is 0.1 bar. Two feed water heaters operate at optimum temperatures. Determine: (1) The quality of steam at turbine exhaust, (2) network per kg of steam, (3) cycle efficiency, (4) the steam rate. Neglect pump work. (8)

14. (a) (i) One kg of CO_2 has a volume of 1 m^3 at 100°C. Compute the pressure by

(1) Van der Waals' equation

(2) Perfect gas equation.

The Van der Waals' constants a = 362850 $Nm^4/(kg\text{-}mol)^2$ and b = 0.0423 $m^3/(kg\text{-}mol)$.

(ii) Write the Berthelot and Dieterici equations

Or

(b) (i) What is Joule-Thomson coefficient? Why is it zero for an ideal gas?

(ii) Derive an expression for Clausius Clapeyron equation applicable to fusion and vapourization.

15. (a) A gas mixture consists of 7 kg nitrogen and 2 kg oxygen, at 4 bar and 27°C. Calculate the mole fraction, partial pressures, molar mass, gas constant, volume and density.

Or

(b) Atmospheric air at 1.0132 bar has a DBT of 30°C and WBT of 25°C. Compute:

(i) the partial pressure of water vapour

(ii) specific humidity

(iii) the dew point temperature

(iv) the relative humidity

(v) the degree of saturation

(vi) the density of air in the mixture

(vii) the density of vapour in the mixture and

(viii) the enthalpy of the mixture. Use the thermodynamic tables only.

PART C — (1 × 15 = 15 marks)

16. (a) (i) A household refrigerator that has a power input of 450 W and a COP of 1.5 is to cool 5 large watermelons, 10 kg each, to 8°C. If the watermelons are initially at 28°C, determine how long it will take for the refrigerator to cool them. The watermelons can be treated as water whose specific heat is 4.2 kJ/kg K. Is your answer realistic or optimistic? Explain. (10)

(ii) What are the desirable characteristics of a working fluid most suitable for vapour power cycles? (5)

Or