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

(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 30s: (8)

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

Question Paper Code : 80653

B.E./B.Tech. DEGREE EXAMINATION, NOVEMBER/DECEMBER 2016.

Third Semester

Mechanical Engineering

ME 6301 – ENGINEERING THERMODYNAMICS

(Common to Automobile Engineering and Mechanical and Automation Engineering)

(Regulations 2013)

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? Explain.

2. What are intensive and extensive properties?

3. A heat engine with a thermal efficiency of 45 percent rejects 500 kJ/kg of heat. How much heat does it receive?

4. When a system is adiabatic, what can be said about the entropy change of the substance in the system?

5. Is iced water a pure substance? Why?

6. What is the effect of reheat on (a) the network output, (b) the cycle efficiency, and (c) steam rate of a steam power plant?

7. What are reduced properties?

8. Write down the two Tds equations.

9. State Dalton's law of partial pressures.

10. What is dew point temperature?

PART B — (5 × 13 = 65 marks)

11. (a) A piston-cylinder device contains 0.15 kg of air initially at 2 MPa and 350°C. The air is first expanded isothermally to 500 kPa, then compressed polytropically with a polytropic exponent of 1.2 to the initial pressure, and finally compressed at the constant pressure to the initial state. Determine the boundary work for each process and the network of the cycle. (13)

Or

(b) (i) Air enters the compressor of a gas-turbine plant at ambient conditions of 100 kPa and 25°C with a low velocity and exits at 1 MPa and 347°C with a velocity of 90 m/s. The compressor is cooled at a rate of 1500 kJ/min, and the power input to the compressor is 250 kW. Determine the mass flow rate of air through the compressor. Assume $c_p = 1.005$ kJ/kg K. (7)

(ii) Derive steady flow energy equation. (6)

12. (a) (i) A heat pump operates on a Carnot heat pump cycle with a COP of 8.7. It keeps a space at 24°C by consuming 2.15 kW of power. Determine the temperature of the reservoir from which the heat is absorbed and the heating load provided by the heat pump. (7)

(ii) An inventor claims to have developed a refrigeration system that removes heat from the closed region at –12°C and transfers it to the surrounding air at 25°C while maintaining a COP of 6.5. Is this claim reasonable? Why? (6)

Or

(b) (i) A 30-kg iron block and a 40-kg copper block, both initially at 80°C, are dropped into a large lake at 15°C. Thermal equilibrium is established after a while as a result of heat transfer between the blocks and the lake water. Determine the total entropy change for this process. (8)

(ii) How much of the 100 kJ of thermal energy at 650 K can be converted to useful work? Assume the environment to be at 25°C. (5)

13. (a) A steam boiler initially contains $5\,m^3$ of steam and $5\,m^3$ of water at 1 Mpa. Steam is taken out at constant pressure until $4\,m^3$ of water is left. What is the heat transferred during the process? (13)

Or

(b) A steam power plant operates on an ideal regenerative Rankine cycle. Steam enters the turbine at 6 MPa and 450°C and is condensed in the condenser at 20 kPa. Steam is extracted from the turbine at 0.4 MPa to heat the feedwater in an open feedwater heater. Water leaves the feedwater heater as a saturated liquid. Show the cycle on a T-s diagram, and determine (i) the network output per kilogram of steam flowing through the boiler and (ii) the thermal efficiency of the cycle. (13)

14. (a) (i) One kg of CO_2 has a volume of $1\,m^3$ at 100°C. Compute the pressure by (9)

(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 of state. (4)

Or

(b) (i) What is Joule-Thomson coefficient? Why is it zero for an ideal gas? (4)

(ii) Derive an expression for Clausius Clapeyron equation applicable to fusion and vapourization. (9)

15. (a) A rigid tank that contains 2kg of N_2 at 25°C and 550 kpa is connected to another rigid tank that contains 4kg of O_2 at 25°C and 150 kPa. The valve connecting the two tanks is opened, and the two gases are allowed to mix. If the final mixture temperature is 25°C, determine the volume of each tank and the final mixture pressure.

Or

(b) It is required to design an air-conditioning plant for a small office room for following winter conditions:

Outdoor conditions ..... 14°C DBT and 10°C WBT

Required conditions ..... 20°C DBT and 60% RH.

Amount of air circulation ... 0.30 m^3/min./person.

Seating capacity of office ... 60.

The required condition is achieved first by heating and then by adiabatic humidifying. Determine the following:

(i) Heating capacity of the coil in kW and the surface temperature required if the by pass factor of coil is 0.4.

(ii) The capacity of the humidifier.