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Question Paper Code : 77207

B.E./B.Tech. DEGREE EXAMINATION, APRIL/MAY 2015.

Third Semester

Mechanical Engineering

ME 6301 — ENGINEERING THERMODYNAMICS

(Common to Automobile Engineering and Mechanical and Automation Engineering)

(Regulation 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 — ($10 \times 2 = 20$ marks)

1. State the first law for a closed system undergoing a process and a cycle.

2. Why does free expansion have zero work transfer?

3. What is a thermal energy reservoir? Explain the term 'source' and 'sink'.

4. What is a reversed heat engine?

5. What is meant by 'dryness fraction of steam'?

6. Draw the standard Rankine cycle on P-v and T-s coordinates.

7. What is Joule-Thomson coefficient? Why is it zero for an ideal gas?

8. What is the law of corresponding states?

9. What is Amagat's law?

10. What is sensible heating?

PART B — (5 × 16 = 80 marks)

11. (a) A gas undergoes a thermodynamic cycle consisting of the following processes :

(i) Process 1-2: Constant pressure $p_1 = 1.4$ bar, $V_1 = 0.028\ m^3$, $W_{12} = 10.5$ kJ.

(ii) Process 2-3: Compression with pV = constant, $U_3 = U_2$.

(iii) Process 3-1: Constant volume, $U_1 - U_3 = -26.4$ kJ.

There are no significant changes in KE and PE

(1) Sketch the cycle on a p-V diagram.

(2) Calculate the network for the cycle in kJ.

(3) Calculate the heat transfer for process 1-2.

(4) Show that $\underset{\text{cycle}}{\Sigma Q} = \underset{\text{cycle}}{\Sigma W}$.

Or

(b) A turbine operating under steady flow conditions receives steam at the following state : pressure 13.8 bar: specific volume 0.143 m^3/kg; internal energy 2590 kJ/kg; velocity 30 m/s. The state of the stream leaving the turbine is : pressure 0.35 bar : specific volume 4.37 m^3/kg : Internal energy 2360 kJ/kg : velocity 90 m/s. Heat is lost to the surroundings at the rate of 0.25 kJ/s. If the rate of steam flow is 0.38 kg/s, what is the power developed by the turbine?

12. (a) A reversible heat engine operates between two reservoirs at temperature of 600°C and 40°C. The engine drives a reversible refrigerator which operates between reservoirs at temperatures of 40°C and –20°C. The heat transfer to the heat engine is 2000 kJ and the network output for the combined engine refrigerator is 360 kJ. Calculate the heat transfer to the refrigerant and the net heat transfer to the reservoir at 40°C.

Or

(b) Two kg of air at 500 kPa, 80°C expands adiabatically in a closed system until its volume is doubled and its temperature becomes equal to that of the surroundings which is at 100 kPa, 5°C. For this process determine :

(i) the maximum work

(ii) the change in availability and

(iii) the irreversibility.

13. (a) A vessel of volume 0.04 m^3 contains a mixture of saturated water and saturated steam at a temperature of 250°C. The mass of the liquid present is 9 kg. Find the pressure, the mass, the specific volume, the enthalpy, and entropy, and the internal energy of the mixture. (16)

Or

(b) A steam power plant operates on a simple ideal Rankine cycle between the pressure limits of 3 MPa and 50 kPa. The temperature of the steam at the turbine inlet is 300°C, and the mass flow rate of steam through the cycle is 35 kg/s. Show the cycle on a T-s diagram with respect to saturation lines, and determine

(i) the thermal efficiency of the cycle and

(ii) the net power output of the power plant.

14. (a) Derive any three of the Maxwell relations.

Or

(b) Determine the pressure of nitrogen gas at $T = 175$ K and $v = 0.00375$ m^3/kg on the basis of

(i) the ideal-gas equation of state (8)

(ii) the van der Waals equation of state.

The van der Waals constants for nitrogen are $a = 0.175$ $m^6.kPa/kg^2$, $b = 0.00138$ m^3/kg. (8)

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.

$(8 \times 2 = 16)$
