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

Question Paper Code : 25146

B.E. DEGREE EXAMINATION, NOVEMBER/DECEMBER 2018.

Third Semester

Mechanical Engineering

ME 8391 – ENGINEERING THERMODYNAMICS

(Common to Industrial Engineering / Automobile Engineering / Mechanical and Automation Engineering)

(Regulations 2017)

Time : Three hours Maximum : 100 marks

(Use of steam table, is allowed)

Answer ALL questions.

PART A — ($10 \times 2 = 20$ marks)

1. What is meant by Control volume and control surface?

2. Using Knudsen number define continuum.

3. Define heat reservoir and source.

4. What is Helmholtz Free Energy Function?

5. What is critical condition of steam?

6. What do you understand by Heat Rate?

7. State the principle of corresponding states.

8. Identify the application of Clausius — Clapeyron equation.

9. What is meant by partial volume?

10. Define adiabatic saturation temperature.

PART B — (5 × 13 = 65 marks)

11. (a) (i) Derive the expression for the displacement work. (5)

(ii) Determine the work transfer and heat transfer for a system in which a perfect gas having molecular weight of 16 kg/kmol is compressed from 101.3 kPa, 20°C to a pressure of 600 kPa following the law $pV^{1.3}$ = constant. Take specific heat at constant pressure of gas as 1.7 kJ/kg.K. (8)

Or

(b) (i) Write the steady flow energy equation and simplify it to be applicable for a gas turbine and a compressor. (5)

(ii) In a gas turbine installation air is heated inside heat exchanger upto 750°C from ambient temperature of 27°C. Hot air then enters into gas turbine with the velocity of 50 m/s and leaves at 600°C. Air leaving turbine enters a nozzle at 60 m/s velocity and leaves nozzle at temperature of 500°C. For unit mass flow rate of air determine the following assuming adiabatic expansion in turbine and nozzle,

(1) heat transfer to air in heat exchanger

(2) power output from turbine

(3) velocity at exit of nozzle.

Take c_p for air as 1.005 kJ/kgK. (8)

12. (a) (i) Show that the efficiency of the reversible heat engine depends only on the maximum and minimum absolute temperature in the cycle. (5)

(ii) A fluid undergoes a reversible adiabatic compression from 4 bar, 0.3 m³ to 0.08 m³ according to the law $pv^{1.25} = C$. Determine the change in enthalpy, the change in internal energy and change in entropy. (8)

Or

(b) (i) State and prove Carnot Theorem. (5)

(ii) Air flows through an adiabatic compressor at 2 kg / s. The inlet condition are 100 kPa and 310 K, and the exit conditions are 700 kPa and 560 K. Consider T_0 to be 298 K. Determine the change of availability and the irreversibility. (8)

13. (a) (i) Explain the process of formation of steam with T-s diagram. (5)

(ii) 3 kg of steam at 18 bar occupy a volume of 0.2550 m³. During a constant volume process, the heat rejected is 1320 kJ. Determine final internal energy also find initial dryness and work done. (8)

Or

(b) Draw the schematic diagram of Rankine cycle and explain its working with the help of h-s diagram. Also discuss Rankine cycle improvements. (13)

14. (a) (i) Deduce Van der Waals equation of state and explain its importance. (5)

(ii) Explain the principle of corresponding states and the use of compressibility chart. (8)

Or

(b) (i) Derive TdS relation in terms of change in T and V. (5)

(ii) Explain Joule — Thomson experiment and deduce the expression for Joule — Thomson coefficient. (3+5)

15. (a) (i) Explain the mole fraction and mass fraction and the relationship between them. (5)

(ii) The exhaust gas of an internal combustion engine is found to have 9.8% CO_2, 0.3% CO, 10.6% H_2O, 4.5% O_2 and 74.8% N_2 by volume. Calculate molar mass and gas constant of the exhaust gas. If the volume flow rate of exhaust gas is 2 m³/h at 100 kPa and 573 K, calculate its mass flow rate. (8)

Or

(b) (i) List various psychrometric processes and state their significance. (5)

(ii) One kg of air at 40°C dry bulb temperature and 50% RH is mixed with 2 kg of air at 20°C DBT and 20°C dew point temperature. Calculate the temperature and specific humidity of the mixture. (8)

PART C — (1 × 15 = 15 marks)

16. (a) In a passenger car, a lead storage battery is able to deliver 5.2 MJ of electrical energy. This energy available is used to start the car. Suppose we wish to use compressed air for doing an equivalent amount of work in starting the car. The compressed air is stored at 7 MPa, 25°C.

Calculate the mass of the air and volume of tank required to have the compressed air having the same availability of 5.2 MJ. Take, 101,325 Pa and 298 K as atmospheric conditions. (15)

Or

(b) A steam power plant running on Rankine cycle has steam entering HP turbine at 20 MPa, 500°C and leaving LP turbine at 90% dryness. Considering condenser pressure of 0.005 MPa and reheating occurring up to the temperature of 500°C. Determine the pressure at which steam leaves HP turbine, the thermal efficiency and work done. (15)