Question Paper Code : 80227

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

Third/ Fourth Semester

Mechanical Engineering

ME 8391 — ENGINEERING THERMODYNAMICS

(Common to: Plastic Technology/ Automobile Engineering/ Industrial Engineering/ Mechanical and Automation Engineering)

(Regulation 2017)

Time : Three hours | Maximum : 100 marks

Use of Standard thermodynamic tables, Mollier diagram and table are permitted.

Answer ALL questions.

PART A — (10 × 2 = 20 marks)

1. Differentiate between Intensive and Extensive properties.

2. State the zeroth law of thermodynamics.

3. Define entropy of a pure substance.

4. What is irreversibility of a process?

5. Write a short note on Mollier chart.

6. List the advantages in superheating of steam.

7. State the assumptions made in deriving ideal gas equation using the kinetic theory of gases.

8. What is Clausius-Claperyon equation?

9. Identify the relationship between the partial pressures of the constituents in gas mixtures.

10. How will you define Psychrometrics?

PART B — (5 × 13 = 65 marks)

11. (a) The gas expanding in the combustion space of a reciprocating engine has an initial pressure of 50 bar and an initial temperature of 1623°C. The initial volume is 50000 mm^3 and the gas expands through a volume ratio of 20 according to the law $pV^{1.25}$ = constant. Calculate

(i) the work transfer and

(ii) heat transfer in the expansion process. Take $R = 270$ J/kgK and $C_V = 800$ J/kg K.

(13)

Or

(b) The power output of an adiabatic steam turbine is 5 MW, and the state of steam entering the turbine is; pressure 2 MPa; Temperature 400°C; velocity 50 m/s; elevation 10 m. The state of the steam leaving the turbine is: pressure 15 kPa; dryness fraction 0.9; velocity 180 m/s; elevation 6 m. Determine,

(i) the change in enthalpy, kinetic energy and potential energy.

(ii) the work done per unit mass of the steam flowing through the turbine.

(iii) the mass flow rate of the steam.

(13)

12. (a) A Carnot heat engine draws heat from a reservoir at temperature 600 K and rejects heat to another reservoir at temperature T_3. The Carnot forward cycle engine drives a Carnot reversed cycle engine or Carnot refrigerator which absorbs heat from reservoir at temperature 300 K and rejects heat to a reservoir at temperature T_3, determine:

(i) The temperature T_3 such that heat supplied to engine Q_1 is equal to the heat absorbed by refrigerator Q_2.

(ii) The efficiency of Carnot engine and C.O.P. of Carnot refrigerator.

(13)

Or

(b) Air expands through a turbine from 500 kPa, 520°C to 100 kPa, 300°C. During expansion 10 kJ/kg of heat is lost to the surroundings which is at 98 kPa, 20°C. Neglecting the kinetic and potential energy changes, determine per kg of air,

(i) The decrease in availability,

(ii) The maximum work, and

(iii) The irreversibility. For air $C_p = 1.005$ kJ/kgK and $h = C_pT$.

(13)

13. (a) The steam conditions at inlet to the turbine are 42 bar and 50https://me the condenser pressure is 0.035 bar. Assume that the steam is just dry saturated on leaving the first turbine, and is reheated to its initial temperature. Calculate the Rankine cycle efficiency and specific steam consumption with reheating by neglecting the pump work using Mollier chart. (13)

Or

(b) A pressure cooker contains 1.5 kg of saturated steam at 5 bar. Find the quantity of heat which must be rejected so as to reduce the quality to 60% dry. Determine the pressure and temperature of the steam at the new state. (13)

14. (a) A vessel of capacity $3\,m^3$ contains 1 kg mole of N_2 at 90°C.

(i) Calculate pressure and the specific volume of the gas.

(ii) If the ratio of specific heats is 1.4, evaluate the values of C_p and C_v

(iii) Subsequently, the gas cools to the atmospheric temperature of 20°C, then evaluate the final pressure of gas.

(iv) Evaluate the increase in specific internal energy, the increase in specific enthalpy, increase in specific entropy and magnitude and sign of heat transfer. (13)

Or

(b) CO_2 flows at a pressure of 10 bar and 180°C into a turbine, located in a chemical plant, and there it expands reversibly and adibatically to a final pressure of 1.05 bar. Calculate the final specific volume, temperature and increase in entropy. Neglect changes in velocity and elevation. If the mass flow rate is 6.5 kg/min, evaluate the heat transfer rate from the gas and the power delivered by the turbine. Assume CO_2 to be a perfect gas and $C_v = 0.837$ kJ/kg K. (13)

15. (a) Atmospheric air at 38°C and 25% relative humidity passes through an evaporator cooler. If the final temperature of air is 18°C, how much water is added per kg of dry air and what is the final relative humidity? (13)

Or

(b) A perfect gas mixture consists of 4 kg of N_2 and 6 kg of CO_2 at a pressure of 4 bar and a temperature of 25°C. Calculate C_v and C_p of the mixture. If the mixture is heated at constant volume to 50°C. Find the change in internal energy, enthalpy and entropy of the mixture. Take: For $N_2 : C_v = 0.745$ kJ/kg K, $C_p = 1.041$ kJ/kg K for $CO_2, C_v = 0.653$ kJ/kg K, $C_p = 0.842$ kJ/kg K. (13)

PART C — (1 × 15 = 15 marks)

16. (a) Two vessels, A and B, both containing nitrogen, are connected by a valve which is opened to allow the contents to mix and achieve an equilibrium temperature of 27°C. Before mixing in vessel A has pressure 1.5 MPa, temperature 50°C, contents 0.5 kg mole and vessel B has pressure 0.6 MPa, temperature 20°C, contents 2.5 kg mole. Compute the final equilibrium pressure, and the amount of heat transferred to the surroundings. If the vessel is perfectly insulated, calculate the final temperature and pressure which would have been reached. Take $\gamma = 1.4$. (15)

Or

(b) An air-water vapour mixture enters an air-conditioning unit at a pressure of 1.0 bar. 38°C DBT, and a relative humidity of 75%. The mass of dry air entering is 1 kg/s. The air-vapour mixture leaves the air-conditioning unit at 1.0 bar, 18°C, 85% relative humidity. The moisture condensed leaves at 18°C. Sketch the process in the psychrometric chart and determine the heat transfer rate for the process. (15)

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 — ($5 \times 13 = 65$ marks)

(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

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

i) 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)

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 × 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 exchange

(2) power output from turbin

(3) velocity at exit

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)

...plain the process of formation of steam with T-s diagram.

(ii) 3 kg of steam at 18 bar occupy a volume of 0.2550 m^3. 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 m^3/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)

Question Paper Code : 20804

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

Third Semester

Mechanical Engineering

ME 6301 — ENGINEERING THERMODYNAMICS

(Common to Automobile Engineering / Mechanical and Automation Engineering)

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

(Regulations 2013)

Time : Three hours | Maximum : 100 marks

Answer ALL questions.

PART A — (10 × 2 = 20 marks)

1. Differentiate between path functions and point functions.

2. What is the work transfer in free expansion process? And why?

3. Compare source with sink.

4. What happens to energy, entropy and energy of an isolated system? and why?

5. What is degree of superheat?

6. What is Carnot vapour cycle? Plot the same on T-s diagram.

7. Define compressibility factor.

8. What is the significance of Clasius-Clapeyron equation?

9. State Dalton's law of partial pressure.

10. What is meant by degree of saturation? List the limiting values.

PART B — (5 × 13 = 65 marks)

11. (a) 5 kg of air at 100 kPa pressure and 333 K temperature is compressed polytropically to pressure 750 kPa as per the law $Pv^{1.3}$. It is then cooled at constant pressure to 333 K. It is then cooled at constant temperature to its original condition. Plot the cycle on p-v diagram, calculate the work in each process and network and heat transfer.

Or

(b) A compressor delivers 720 kg of air per hour. Air enters at a velocity of 12 m/s, pressure of 1 bar and specific volume of 0.5 m^3/kg, leaves at a velocity of 90 m/s, pressure of 8 bar and specific volume of 0.14 m^3/kg. The increase in enthalpy of air passing through the air compressor is 150 kJ/kg and heat loss to the surroundings is 12 kJ/s. Find: (i) power required to drive the compressor; (ii) ratio of inlet to outlet pipe diameter.

12. (a) If three Carnot engines of same efficiency connected in series such that the 1200 K reservoir supplies 2400 kJ of heat and 150 K reservoir receives 300 kJ of heat, find out the intermediate temperatures, the efficiency and the work output of all the engines.

Or

(b) Air flows through an adiabatic compressor at 2 kg/s. The inlet conditions 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 in availability and the irreversibility.

13. (a) A cylinder with piston contains steam at 8 bar and 435°C. If it is cooled to 200°C at constant pressure, calculate the heat and work transfer per kg and their directions.

Or

(b) In a reheat Rankine cycle, steam enters the steam turbine at 30 bar and 400°C and expands in a high pressure steam turbine to an intermediate pressure of 3 bar at which it is reheated to 400°C before entering the low pressure turbine. The condenser pressure is 0.5 bar. If the mass flow rate of steam is 40 kg/s. calculate the specific steam consumption, the net work per kg, the power output and the thermal efficiency.

14. (a) 5 kmol of carbon monoxide is stored in a 1.135 m^3 container at 215 K. Determine the pressure using (i) ideal gas equation and (ii) van der Waals equation. The constants in the van der Waals equation are 146.3 $kPa.m^6/kmol^2$ and 0.0394 $m^3/kmol$.

Or

(b) Derive the four Maxwell's relations.

15. (a) Atmospheric air at 101.325 kPa and 288.15 K contains 21% oxygen and 79% nitrogen by volume. Calculate the (i) mole fractions and partial pressures of oxygen and nitrogen and (ii) molar mass, gas constant and density of the air. Take molar mass of oxygen and nitrogen as 32 and 28 kg/kmol.

Or

(b) If the air flow of 1800 m^3/h at 35°C and RH of 50% is mixed with another air stream of 2100 m^3/h of air whose both dry and wet temperatures are 20°C. If the pressure is constant at 1 atm, calculate (i) the dry bulb temperature (ii) the relative humidity (iii) the specific humidity (iv) the volume flow rate of the mixture.

PART C — (1 × 15 = 15 marks)

16. (a) An adiabatic air compressor is to be powered by a direct-coupled adiabatic steam turbine that is also driving a generator. Steam enters the turbine at 12.5 MPa and 500°C at a rate of 25 kg/s and exits at 10 kPa and a quality of 0.92. Air enters the compressor at 98 kPa and 295 K at a rate of 10 kg/s and exits at 1 MPa and 620 K. Determine the net power delivered to the generator by the turbine.

Or

(b) During an experiment conducted in a room at 25°C, a laboratory assistant measures that a refrigerator that draws 2 kW of power has removed 30,000 kJ of heat from the refrigerated space, which is maintained at –30°C. The running time of the refrigerator during the experiment was 20 min. Determine if these measurements are reasonable.

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Question Paper Code : 90356

B.E./B.Tech. DEGREE EXAMINATIONS, NOVEMBER/ DECEMBER 2019

Third/Fourth Semester

Mechanical Engineering

ME 8391 – ENGINEERING THERMODYNAMICS

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

(Regulations 2017)

Time : Three Hours Maximum : 100 Marks

Use of Steam table/Mollier chart/Psychrometric chart allowed.

Answer ALL questions.

PART – A **(10×2=20 Marks)**

1. Differentiate between closed system and open system.

2. State Zeroth law of thermodynamics.

3. What is the function of refrigerator ? How is its COP defined ?

4. Why does the entropy of actual universe always increase ?

5. What is the latent heat of evaporation ?

6. Why does Rankine cycle have lower efficiency compared to Carnot cycle ?

7. When does real gas behave like ideal gas and why ?

8. List various thermodynamic potentials used for deriving Maxwell's relations.

9. State Amagat's law of partial volumes.

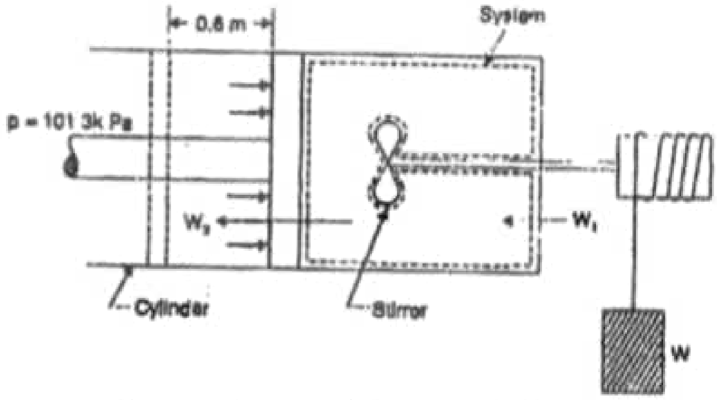
10. What is the effect of adiabatic saturation process ?

PART – B

(5×13=65 Marks)

11. a) i) State first law of thermodynamics and specify its applications. **(3+2)**

ii) A piston and cylinder machine containing a fluid system has a stirring device as shown in Fig.



The piston is frictionless, and it is held down against the fluid due to atmospheric pressure of 101.3 kPa. The stirring device is turned 9500 revolutions with an average torque against the fluid of 1.25 Nm. Meanwhile the piston of 0.65 m diameter moves out 0.6 m. Find the network transfer for the system. **(8)**

(OR)

b) i) Prove that for a steady flow system with negligible change in kinetic and potential energy, the shaft work per kg can be expressed as $W_s = -\int v\,dp$ **(5)**

ii) A working substance flows at a rate of 5 kg/s into a steady flow system at 6 bar 2000 kJ/kg internal energy and 0.4 m^3/kg specific volume with a velocity of 300 m/s. It leaves at 10 bar, 1600 kJ/kg of internal energy, 1.2 m^3/kg of specific volume with a velocity of 150 m/s. The inlet is 10 m above the outlet. The work transfer to the surroundings is 3 MW. Evaluate the change in enthalpy and estimate the heat transfer and indicate the direction. **(8)**

12. a) Draw the Carnot cycle on p-V and T-s Diagram to derive its efficiency and explain the major inference from Carnot cycle efficiency. **(3+3+4+3)**

(OR)

b) Two Carnot engines work in series between the source and sink temperatures of 550 K and 350 K. If both engines develop equal power, draw the schematic and label them properly and also determine the intermediate temperature. **(3+2+8)**

13. a) Draw the p-v-T surface for a normal substance and explain the formation of the superheated steam from ice at constant pressure. **(8+5)**

(OR)

b) A pressure cooker contains 1.5 kg of saturated steam at 5 bar. Find the quantity of heat which must be rejected so as to reduce the quality to 60% dry. Determine the pressure and temperature of the steam at the new state. **(7+3+3)**

14. a) Describe the use of reduced properties, principle of corresponding states and compressibility chart. **(3+6+4)**

(OR)

b) Derive the TdS relation in terms of T and V and hence deduce the expression for change in the internal energy per unit change in volume at constant temperature. **(8+5)**

15. a) i) State Dalton's law and prove the same. **(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 2m^3/h at 100 kPa and 573 K, calculate its mass flow rate. **(8)**

(OR)

b) i) Describe the adiabatic Mixing of Air Streams. **(5)**

ii) An air-water vapour mixture enters an air-conditioning unit at a pressure of 1.0 bar 38°C DBT, and a relative humidity of 75%. The mass of dry air entering is 1 kg/s. The air-vapour mixture leaves the air-conditioning unit at 1.0 bar, 18° C, 85% relative humidity. The moisture condensed leaves at 18°C. Determine the heat transfer rate for the process. **(8)**

PART – C **(1×15=15 Marks)**

16. a) A Carnot heat engine works between two temperature of source at 900 K and sink at 300 K. It operates a Carnot refrigerator working between two temperatures of 300 K and 250 K. The heat engine is supplied with 50 kJ/s and it not only operates refrigerator, but also delivers a net power of 10 kW. i) Determine the heat transferred to the refrigerant in the refrigerator and the net heat transfer to the sink maintained at 300 K. ii) Recalculate the above, if the actual efficiency of the heat engine is 50% of the maximum value and COP of the refrigerator is 50% of the maximum value. **(8+7)**

(OR)

b) In a power station, the saturated steam is generated at 200°C by transferring the heat from hot gases in a steam boiler. The gases are cooled from 1000°C to 500°C and all the heat from gases goes to water. Assume water enters the boiler at saturated condition and leaves as saturated steam. i) Calculate the mass of gas required to produce a kg of steam and ii) Find the increase in total entropy of the combined system of gas and water and increase in unavailable energy due to irreversible heat transfer. Take C_p (for gas) = 1.0 kJ/kg.K, h_{fg} (latent heat of steam at 200°C) = 1940.7 kJ/kg. **(8+4+3)**

Question Paper Code : 91835

B.E./B.Tech. DEGREE EXAMINATIONS, NOVEMBER/DECEMBER 2019
Third Semester
Mechanical Engineering
ME 6301 – ENGINEERING THERMODYNAMICS
(Common to Automobile Engineering/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. 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 triple point ? For a pure substance, how many degrees of freedom are there at triple point.

4. A vessel of 2 m^3 contains a wet steam of quality 0.8 at 210° C. Determine the mass of the liquid and vapour present in the vessel.

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 ? Give their significance.

8. What is the importance of Joule-Thomson coefficient ?

9. State and prove the Amagat's law of partial volume.

10. What is sensible cooling ?

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) Discuss about clausius inequality. **(7)**

ii) With suitable examples explain high and low grade energy. **(6)**

(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)**

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, the entropy and the internal energy. **(13)**

(OR)

b) A reheat Rankine cycle receives steam at 35 bar and 0.1 bar. Steam enters the first stage steam turbine 350°C. If reheating is done at 8 bar to 350°C, calculate the specific steam consumption and reheat Rankine cycle efficiency. **(13)**

14. a) i) A vessel of volume 0.28 m^3 contains 10 kg of air at 320 K. Determine the pressure exerted by the air using a) perfect gas equation b) Vander walls equation c) Generalised compressibility chart. (Take critical temperature of air as 132.8 K and critical pressure of air as 37.7 bar). **(8)**

ii) Draw a neat schematic of a compressibility chart and indicate its salient features. **(5)**

(OR)

b) What is meant by phase change process ? Derive Clausius-Clapeyron equation for a phase change process. Give the significance of this equation. **(13)**

15. a) In an engine cylinder a gas has a volumetric analysis of 13% CO_2, 12.5% O_2 and 74.5% N_2. The temperature at the beginning of expansion is 950°C and the gas mixture expands reversibly through a volume ratio of 8:1, according to the law $pv^{1.2}$ = constant. Calculate per kg of gas :

i) The work done.

ii) The heat flow

iii) Change of entropy per kg of mixture.

The values of c_p for the constituents CO_2, O_2 and N_2 are 1.235 kJ/kg K, 1.088 kJ/kg K and 1.172 kJ/kg K respectively. **(13)**

(OR)

b) With the help of psychrometric chart discuss the following :

Simple heating and humidification process and

Simple cooling and dehumidification process **(13)**

PART – C **(1×15=15 Marks)**

16. 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. **(15)**

(OR)

b) i) The sling psychrometer in a laboratory test recorded the following readings :

Dry bulb temperature = 35° C

Wet bulb temperature = 25° C

Calculate the following :

1) Specific humidity

2) Relative humidity

3) Vapour density in air

4) Dew point temperature

5) Enthalpy of mixture per kg of dry air

Take atmostpheric pressure = 1.0132 bar **(10)**

ii) Write a short note on mixing of air streams in psychrometry. **(5)**

Question Paper Code : X20833

B.E./B.Tech. DEGREE EXAMINATIONS, NOVEMBER/DECEMBER 2020
AND APRIL/MAY 2021
Third Semester
Mechanical Engineering
ME 6301 – ENGINEERING THERMODYNAMICS
(Common to Automation Engineering, Mechanical and Automation Engineering)
(Regulations 2013)
(Also common to PTME 6301 – Engineering Thermodynamics for B.E. Part time
– Second Semester – Mechanical Engineering – Regulations 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. Write down the equation for first law for a steady flow process.

2. Give the energy equation applicable for an adiabatic nozzle and an adiabatic turbine.

3. What is PMM2 ?

4. What do you understand by high grade energy and low grade energy ?

5. Define Degree of saturation.

6. State Gibbs-Dalton's law.

7. What are reduced properties ?

8. Write down the two Tds equations.

9. What is Amagat's law ?

10. What is sensible heating ?

PART – B **(5×13=65 Marks)**

11\. a) A mass of air is initially at 260 °C and 700 kPa and occupies 0.028 m^3. The air is expanded at constant pressure to 0.084 m^3. A polytropic process with n = 1.5 is then carried out followed by a constant temperature process which completes a cycle. All the process are reversible.

1) Sketch the cycle in T-S and P-V planes. **(4)**
2) Find the heat received and heat rejected in the cycle. **(4)**
3) Find the efficiency of the cycle. **(5)**

(OR)

b) i) A room for four person has 2 fans, each consuming 0.18 kW power, and three 100 W lamps. Ventilation air at the rate of 80 kg/hr enters with an enthalpy of 84 kJ/kg and leaves with an enthalpy of 59 kJ/kg. If each person puts out heat at the rate of 630 kj/hr. Determine the rate at which heat is removed by a room cooler, so that a steady state is maintained in the room. **(6)**

ii) An insulated rigid tank of 1.5 m^3 of air with a pressure of 6 bar and 100°C discharges air 1 to the atmosphere which is at 1 bar through a discharge pipe till its pressure becomes 1 bar.

1) Calculate the velocity of air in the discharge pipe. **(3)**
2) Evaluate the work that can be obtained from the frictionless turbine using the kinetic energy of that air. **(4)**

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 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.

(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) Draw the p-V, T-S, h-S diagrams and theoretical lay out for Rankine cycle and hence deduce the expression for its efficiency.

(OR)

b) i) State the advantages of using super heated steam in vapour power cycles. **(5)**

ii) A vessel with a capacity of 0.05 m^3 contains a mixture of saturated water and saturated steam at a temperature of 245°C. The mass of the liquid present is 10 kg. Find the following:

1) The pressure,

2) The mass,

3) The specific volume

4) The specific enthalpy,

5) The specific entropy, and

6) The specific internal energy. **(8)**

15. a) Atmospheric air at 101.325 kPa and 288.15 K contains 21% oxygen and 79% nitrogen, by volume. Calculate the

i) Mole fractions, mass fractions and partial pressures of oxygen and nitrogen and

ii) Molar mass, gas constant and density of the air.
Take molar mass of oxygen and nitrogen as 32 and 28 kg/kmol.

(OR)

b) Air at 20°C, 40% RH is mixed adiabatically with air at 40°C, 40% RH in the ratio of 1 kg of the former with 2 kg of the latter (on dry basis). Determine the specific humidity and the enthalpy of the mixed stream.

PART – C **(1×15= 15 Marks)**

16. a) A quantity of air undergoes a thermodynamic cycle consisting of three processes. Process 1 – 2 : Constant volume heating from P_1 = 0.1 MPa, T_1 = 15°C, V_1 = 0.02 m^3 to P_2 = 0.42 MPa. Process 2-3 : Constant pressure cooling. Process 3-1 : Isothermal heating to the initial state. Employing the ideal gas model with C_p = 1 kJ/kgK, evaluate the change of entropy for each process. Sketch the cycle on p-v and T-s coordinates.

(OR)

b) Air at 80 kPa, 27°C and 220 m/s enters a diffuser at a rate of 2.5 kg/s and leaves at 42°C. The exit area of the diffuser is 400 cm^2. The air is estimated to lose heat at a rate of 18 kJ/s during this process. Determine :

i) The exit velocity and

ii) The exit pressure of the air.

Question Paper Code : X10694

B.E./B.Tech. DEGREE EXAMINATIONS – NOV / DEC 2020 AND APRIL / MAY 2021

Third / Fourth Semester

Mechanical Engineering

ME8391 - ENGINEERING THERMODYNAMICS

(Common to Automobile Engineering, Mechanical and Automation Engineering, Industrial Engineering and Plastic Technology)

(Regulations 2017)

Time: 3 Hours | Answer ALL Questions | Max. Marks 100

PART- A (10 x 2 = 20 Marks)

1. What is meant by intensive property in thermodynamics? Give two examples.
2. State the significance of Zeroth law of thermodynamics.
3. A reversible heat engine is operated with an efficiency of 25%. If it is operated as reversible refrigerator between the same temperature limits, what is its COP?
4. How does entropy of isolated system change? Why?
5. What is critical condition in phase change in thermodynamics?
6. What is the effect of reheating on network and efficiency of Rankine cycle?
7. What are the two distinct features of real gas?
8. What is the compressibility factor of Vander Walls' gas at critical point?
9. How does gas constant depend on molecular mass of the gas?
10. What is the need for dehumidification during summer air conditioning?

PART- B (5 x 13 = 65 Marks)

11. a) i) State first law of thermodynamics and list its limitations. **(2+3)**

ii) A fluid in a piston and cylinder executes 220+ cycles per min with four processes. The net heat transfer during a cycle is -300kJ. Complete the following table showing the method for each item, and compute the net rate of work output in kW. **(8)**

Process	Q(kJ/min)	W(kJ/min)	ΔE(kJ/min)
1-2	0	4350	?
2-3	42000	0	?
3-4	-4200	?	-73500
4-1	?	?	?

OR

i) Derive steady flow energy equation per unit mass and show that shaft work produced by a gas turbine is equal to the enthalpy drop across the gas turbine. **(3+2)**

ii) A blower handles 1 kg/s of air at 293 K and consumes a power of 15kW. The inlet and outlet velocities of the air are 100 m/s and 150 m/s respectively. Find the exit air temperature and the pressure ratio, assuming Adiabatic conditions. Take C_p = 1.005kJ/kg. **(5+3)**

12. a) i) State and derive Clausius inequality. **(2+3)**

ii) A reversible engine operates between a source at 972°C and two sinks, one at 127°C and another at 27°C. The energy rejected is same at both the sinks. Compute the engine efficiency. Also calculate the power and rate of heat supply if the rate of heat rejected to each sink is100 kW. **(4+4)**

OR

b) i) Draw the Carnot cycle on p-V and T-s diagram and derive the efficiency of Carnot cycle based on T-s diagram. **(2+3)**

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

13. a) i) Explain the use of Throttling Calorimeter to determine dryness fraction. **(5)**

ii) Steam flows through a small turbine at the rate of 500 kg/h entering at 15 bar, 300°C and leaving gat 0.1 bar with 4% moisture. The steam enters at 80 m/s at a point 2 m above the discharge and leaves at 40 m/s. Compute the shaft power assuming that the device is adiabatic but considering kinetic and potential energy changes. Calculate the areas of the inlet and discharge tubes. **(8)**

) i) Draw Rankine Cycle on T-s and H-s diagram with steam at superheated condition at the entry of turbine and explain the effect of super heated steam on network and efficiency, compared to saturated steam based Rankine cycle. **(5)**

ii)Steam enters the turbine at 3 MPa and 400°C and is condensed at 10 KPa. Some quantity of steam leaves the turbine at 0.6 MPa and enters open feed water heater. Compute the fraction of the steam extracted per kg of steam and cycle thermal efficiency. **(8)**

14. a) i) Deduce the value of Van der Waals' constant in terms of critical properties. **(5)**

ii) Explain reduced properties and their uses in generalised compressibility chart. List the advantages of generalized compressibility chart. **(8)**

OR

b) i) Deduce the expression for the change in internal energy with respect to change in volume at constant temperature. **(5)**

ii) The latent heat of vaporization at 1 bar pressure is 2258kJ/kg and the saturation Temperature is 99.4°C. Calculate the saturation temperature at 2 bar pressure. Verify the same from the steam table data. **(8)**

15. a) i) State Amagat's Law and Dalton's Law. **(5)**

ii) A closed vessel has a capacity of 500 litres. It contains 20% nitrogen and 20% oxygen, 60% carbon di-oxide by volume at 100°C and 1 MPa. Calculate the molecular mass, gas constant, mass percentages and the mass of mixture. **(8)**

OR

b) i) Define relative humidity and show on the psychrometric chart how it changes during sensible heating, sensible cooling, humidification and dehumidification. **(5)**

ii) $120m^3$ of air per minute at 35°C DBT and 50% relative humidity is cooled to 20°C DBT by passing through a cooling coil. Determine the following:-

i) Relative humidity of out coming air,

ii) Wet bulb temperature of out coming air, (4)

iii) Capacity of cooling coil in tonnes of refrigeration, taking 14000 kJ/hr as one tonne of refrigeration.

PART- C (1 x 15 = 15 Marks)

16. a) The air speed of a turbo jet engine in flight is 270 m/s. Ambient Air temperature is -15°C. Gas temperature at the outlet of the nozzle is 600°C. Corresponding enthalpy values for air and gas are 260 and 912 kJ/kg respectively. Fuel-air ratio is 0.019. Chemical energy in the fuel is 44.5 MJ/kg. Owing to incomplete combustion 5% of the chemical energy is not released in the reaction. Heat loss from the engine is 21kJ/kg of air.

i) Draw the schematic diagram and indicate all the mass and energy interactions taking jet engine as a system. (5)

ii) Calculate the velocity of the exhaust jet. (5)

iii) Also calculate the thrust per unit mass flow rate of air, given that the thrust is the forward force on jet engine due to rate of change of momentum of working fluid. (5)

OR

b) It is required to design an air-conditioning system for an industrial process for the following hot and wet summer conditions with the use of psychometric chart:

Outdoor conditions..............32°C DBT and 65% R.H

Required air inlet conditions......25°C DBT and 60% R.H.

Coil dew point temperature..................13°C

The required condition is achieved by first cooling and dehumidifying and then by heating. Hence, calculate the following:

i) The cooling capacity of the cooling coil and its by-pass factor. (5)

ii) Heating capacity of the heating coil in kW and surface temperature of the heating coil if the by-pass factor is 0.3. (5)

iii) The mass of water vapour removed per hour. (5)

Question Paper Code : 70147

B.E./B.Tech. DEGREE EXAMINATIONS, NOVEMBER/DECEMBER 2022.

Third Semester

Mechanical Engineering

ME 3391 — ENGINEERING THERMODYNAMICS

(Common to Mechanical Engineering (Sandwich))

(Regulations 2021)

Time : Three hours | Maximum : 100 marks

Use of steam table permitted.

Answer ALL questions.

PART A — ($10 \times 2 = 20$ marks)

1. What is equation of state? Write equation of state for ideal gas.

2. Compare path functions and point functions.

3. Define Kelvin-Planck statement of second law of thermodynamics.

4. Prove $COP_{HP} = COP_{R} + 1$.

5. What is available energy?

6. Define the second law efficiency for a work producing device.

7. Define dryness fraction.

8. A saturated steam has entropy of 6.76 kJ/kg K. What are its pressure, temperature and specific volume?

9. What is the importance of Joule-Thomson coefficient?

10. Consider a gas mixture that consists of 3kg of O_2, 5 kg of N_2 and 12 kg of CH_4. Determine the mass fraction of each component.

PART B — (5 × 13 = 65 marks)

11. (a) (i) A mass of 15 kg of air in a piston-cylinder device is heated from 25 to 95°C by passing current through a resistance heater inside the cylinder. The pressure inside the cylinder is held constant at 300 kPa during the process, and a heat loss of 60 kJ occurs. Determine the electric energy supplied, in kWh. (8)

(ii) In the compression stroke of an internal combustion engine the heat rejected to the cooling water is 35 kJ/kg and the work input is 100 kJ/kg. Find the change in specific internal energy of the working fluid. (5)

Or

(b) (i) An adiabatic air compressor compresses 10 L/s of air at 120 kPa and 20°C to 1000 kPa and 300°C. Determine

(1) The work required by the compressor, in kJ/kg, and

(2) The power required to drive the air compressor, in kW. (8)

(ii) Simplify the steady flow energy equation applied to a adiabatic nozzle with negligible potential energy. (5)

12. (a) A reversible heat engine operates between two thermal reservoirs at temperature 1000 K and 300 K. The engine drives a reversible refrigerator which operates between reservoirs at temperatures 250 K and 300 K. The heat transfer to the heat engine is 2000 kJ and the net work output of combined engine-refrigerator plant is 360 kJ. Evaluate the heat transfer to the refrigerant, (COP) of the refrigerator and heat transfer to the 300 K reservoir.

Or

(b) A power cycle operating between two thermal reservoirs receives energy Q_H by heat transfer from a hot reservoir at T_H = 2000 K and rejects energy Q_C by heat transfer to a cold reservoir at T_C = 400 K. For each of the following cases determine whether the cycle operates reversibly. operates irreversibly, or is impossible.

(i) Q_H = 1000 kJ, η = 60%

(ii) Q_H = 1000 kJ, W_{cycle} = 850 kJ

(iii) Q_H = 1000 kJ, Q_C = 200 kJ.

13. (a) A 50-kg block of iron casting at 500 K is thrown into a large lake that is at a temperature of 285 K. The iron block eventually reaches thermal equilibrium with the lake water. Assuming an average specific heat of 0.45 kJ/kg K for the iron, determine

(i) The entropy change of the iron block,

(ii) The entropy change of the lake water, and

(iii) The entropy generated during this process.

Or

(b) A heat engine receives heat from a source at 1200 K at a rate of 500 kJ/s and rejects the waste heat to a medium at 300 K. The power output of the heat engine is 180 kW. Determine the reversible power, the irreversibility rate for this process and second law efficiency.

14. (a) An insulated piston-cylinder device initially contains 1.8 kg of saturated liquid water at 120°C. Now an electric resistor placed in the cylinder is turned on for 10 min until the volume quadruples. Determine

(i) the volume of the cylinder,

(ii) the final temperature, and

(iii) the electrical power rating of the resistor.

Or

(b) Steam initially at 1.5 MPa, 573 K expands reversibly and adiabatically in a steam turbine to 313 K. Determine the ideal work output of the turbine per kg of steam.

15. (a) A rigid tank contains 2 kmol of N_2 and 6 kmol of CO_2 gases at 300 K and 15 MPa. Estimate the volume of the tank on the basis of

(i) The ideal-gas equation of state,

(ii) Compressibility factors Amagat's law.

Or

(b) Two grams of a saturated liquid are converted to a saturated vapor by being heated in a weighted piston-cylinder device arranged to maintain the pressure at 200 kPa. During the phase conversion, the volume of the system increases by 1000 cm^3, 5 kJ of heat are required; and the temperature of the substance stays constant at 80°C. Estimate the boiling temperature of this substance when its pressure is 180 kPa.

PART C — (1 × 15 = 15 marks)

16\. (a) A piston and cylinder machine contains a fluid system which passes through a complete cycle of four processes. During a cycle, the sum of all heat transfer is (–170 kJ). The system completes 100 cycle per minute. Complete the following tables showing the method for each item, and compute the net rate if work output in kW.

Process	Q (kJ/min)	W (kJ/min)	Δ E (kJ/min)
a-b	0	2,170	–
b-c	21,000	0	–
c-d	–2,100	–	–36,600
d-a	–	–	–

Or

(b) A piston cylinder device initially contains 1.5 kg of liquid water at 150 kPa and 20°C. The water is now heated at constant pressure by the addition of 4000 kJ of heat. Determine the entropy change of water during this process.