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APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY

Fourth Semester B.Tech Degree Examination June 2022 (2019 scheme)

Course Code: MET202

Course Name: ENGINEERING THERMODYNAMICS

Max. Marks: 100 Duration: 3 Hours

(Use of steam tables & Mollier chart and compressibility chart permitted)

PART A

(Answer all questions; each question carries 3 marks) Marks

1	Distinguish between thermodynamic system and control volume	3
2	Describe quasi static process undergone by a system with the help of neat sketches including the *pv* diagram.	3
3	Derive the equation for *pdv* work in a polytropic expansion process	3
4	State and explain the first law of thermodynamics for a closed system undergoing a cyclic process with the help of neat sketches	3
5	Distinguish between reversible and irreversible processes with the help of neat sketches.	3
6	Define a PMM2. Why is it impossible?	3
7	What are steam tables and saturation states? What for they are used?	3
8	Draw the T-s plot of a pure substance, and show various constant property lines on it.	3
9	Draw the isenthalpic curve and inversion curve in the *T-p* coordinates. Explain how these curves are obtained?	3
10	Derive the Clausius-Clapeyron equation from the first *T-ds* equation. What is the significance of this equation?	3

PART B

(Answer one full question from each module, each question carries 14 marks)

Module -1

11 a) Define the following terms associated with a thermodynamic system: 7

i. Properties.

ii. State

iii. Path

iv. Process

v. Cycle

vi. Intensive property (give at least one example)

vii. Extensive property (give at least one example)

b) What was the temperature measurement method used before 1954? Derive the equation used for temperature measurement in this method. 7

12 a) i) What do you mean by thermodynamic equilibrium of a system? What are the conditions required for a system to exist in thermodynamic equilibrium? Explain. 7

ii) Consider a system whose temperature is 18°C. Express this temperature in R, K, and °F.

b) i) The temperature t on a thermometric scale is defined in terms of a property K by the relation 7

$$t = a \ln K + b$$

where a and b are constants.

The values of K are found to be 1.83 and 6.78 at the ice point and the steam point, the temperatures of which are assigned the numbers 0 and 100 respectively. Determine the temperature corresponding to a reading of K equal to 2.42 on the thermometer.

ii) What is the working principle of a constant volume gas thermometer? Explain with neat sketches.

Module -2

13 a) i) Give an account of various forms of energy that may be stored in a system. Write the first law equation for a system undergoing change of state accounting all forms of above energies. 7

ii) Assume that a battery is connected to an external electrical load in a closed circuit for a period of time so that the battery is discharged as a result of the electric current flow. Apply first law of thermodynamics for this case, assuming no dissipation of energy into heat.

b) A turbine operates under steady flow conditions, receiving steam at the following state: Pressure 1.2 MPa, temperature 188°C, enthalpy 2785 kJ/kg, velocity 33.3 m/s and elevation 3 m. The steam leaves the turbine at the following state: Pressure 20 kPa, enthalpy 2512 kJ/kg, velocity 100 m/s and elevation 0 m. Heat is lost to 7 the surroundings at the rate of 0.29 kJ/s. If the rate of steam flow through the turbine is 0.42 kg/s, what is the power output of the turbine in kW?

14 a) Derive the general energy equation for a variable flow process using control volume technique. What happens to this equation for a steady flow? 7

b) i) 1.5 kg of liquid having a constant specific heat of 2.5 kJ/kgK is stirred in a well-insulated chamber causing the temperature rise by 15°C. Find ΔE and W for the process. 7

If the same liquid is stirred in a conducting chamber, the temperature of the liquid is increased to 15°C, and the heat transfer from the liquid to the surroundings was 1.7 kJ. Find ΔE and W for the process

ii) The properties of a certain fluid are related as follows:

$$u = 196 + 0.718\, t$$

$$pv = 0.287\,(t + 273)$$

where u is the specific internal energy (kJ/kg), t is in °C, p is pressure (kN/m^2) and v is the specific volume (m^3/kg). For this fluid, find c_v and c_p.

Module -3

15 a) With the help of neat sketches, prove that Kelvin Planck and Clausius statements of second law are equivalent. (Both the proofs are required) 7

b) Prove the inequality of Clausius for defining the reversibility condition for a cycle. Write also the criterion for reversible cycle, irreversible cycle and impossible cycle 7

16 a) A fluid undergoes a reversible adiabatic compression from 0.5 MPa, 0.2 m^3 to 0.05 m^3 according to the law, $pv^{1.3}$=constant. Determine the change in enthalpy, internal energy, entropy, heat transfer and the work transfer during the process. 7

b) With neat sketches, explain the concept of construction of absolute thermodynamic temperature scale between the ice point and the steam point. 7

Module -4

17 a) Explain the *p-v* diagram of a pure substance other than water with the help of neat sketches. Write the critical pressure, critical temperature, and critical volume of water? 7

b) Steam initially at 0.3 MPa, 250°C is cooled at constant volume. Determine the following: 7

(a) At what temperature will the steam become saturated vapor?

(b) What is the quality at 80°C?
(c) What is the heat transferred per kg of steam in cooling from 250°C to 80°C?

18 a) i) What are Virial equations of state? 7

ii) Define compressibility factor.

Also derive the relation between Virial expansion coefficients B' and B, C' and C, and D' and D for a real gas

b) Derive the equation of law of corresponding states from Vander Waals equation of state? What is the significance of this expression? Explain. 7

Module -5

19 a) i) State and derive Dalton's law of partial pressures and Amagat's law of partial volumes for an ideal gas mixture. 7

ii) Derive the expression for partial pressure of component gas in terms of mole fraction

b) A vessel is divided into three compartments (a), (b), (c) by two partitions. Part (a) contains oxygen and has a volume of 0.1 m^3, Part (b) has a volume of 0.2 m^3 and contains nitrogen, while part (c) is 0.05 m^3 and holds CO_2. All three parts are at a pressure of 2 bar and a temperature of 13°C. When the partitions are removed and the gases mix, determine the change in entropy of each constituent, the final pressure in the vessel and the partial pressure of each gas. The vessel may be taken as being completely isolated from its surroundings. 7

20 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, the details of gases in the two vessels are as given below: 7

Vessel A	Vessel B
p = 1.5 MPa	p = 0.6 MPa
t = 50°C	t = 20°C
Contents = 0.5 kg mol	Contents = 2.5 kg

Calculate the final equilibrium pressure and the amount of heat transferred to the surroundings. Take $\gamma = 1.4$

b) Derive the *TdS* equations for a pure substance undergoing an infinitesimal reversible process. 7

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