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Reg No.:_____ Name:_____

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY

B.Tech Degree S4 (S, FE) / S2 (PT) (S, FE) / S4 (WP) (S) Examination December 2024 (2019 Scheme)

Course Code: MET202

Course Name: ENGINEERING THERMODYNAMICS

Max. Marks: 100 Duration: 3 Hours

(Permitted to use Steam tables and Mollier charts)

PART A

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

1		Define control volume and control mass with examples.	3
2		Explain Zeroth law of Thermodynamics and its applications .	3
3		Derive the equation for work transfer for a closed system undergoing a reversible adiabatic process.	3
4		Write the steady flow energy equation and describe each term.	3
5		Explain the principle of increase of entropy of the universe with an example.	3
6		Give the Kelvin-Planck and Clausius' statements of second law of thermodynamics.	3
7		With a sketch explain the Mollier diagram.	3
8		With a sketch explain the P-v diagram for a pure substance.	3
9		Explain Kay's rule of real gas mixtures	3
10		Write notes on Helmholtz and Gibb's functions	3

PART B

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

Module -1

11	a)	Explain quasi-static process with a sketch.	6
	b)	With a neat sketch, describe any four temperature measuring devices.	8
12	a)	Differentiate intensive and extensive properties. Give three examples for each.	6
	b)	Two readings tA and tB of two thermometers A and B agree at ice point and steam points, and is related by the equation $tA = l + mtB + ntB^2$, where l, m, n are	8

constants. When both are immersed in an oil, A reads 51^0C and B reads 50^0C. Determine the reading on A when B reads 25^0C.

Module -2

13 a) Show that heat transfer is a path function. 6

b) A fluid is confined in a cylinder by a spring- loaded frictionless piston so that the pressure in the fluid is a linear function,of the volume $(p = a + b\ V)$. The internal energy of the fluid is given by the equation $U=34+3.15pV$, where U is in kJ, p in kPa, and V in cubic metre. If the fluid changes from an initial state of 170 kPa, 0.03 m^3 to a final state of 400 kPa, 0.06 m^3, with no work other than that done on the piston, find the direction and magnitude of the work and heat transfer. 8

14 a) Air flows steadily at the rate of 0.5 kg/s through an air compressor, entering at 7m/s velocity, 100 kPa pressure, and 0.95 m^3/kg volume, and leaving at 5 m/s, 700 kPa, and 0.19 m^3/kg. The internal energy of the leaving air is 90 kJ/kg greater than that of the entering air. Cooling water in the compressor jackets absorbs heat from the air at the rate of 58 kW. (a) Compute the rate of shaft work input to the air in kW. (b) Find the ratio of the inlet pipe diameter to outlet pipe diameter. 7

b) An insulated storage tank that is initially evacuated is connected to a supply line carrying a fluid at a specific internal energy u_i and specific enthalpy h_i. The valve is opened and the fluid flows into the tank from the supply line and reaches the pressure same as that of the supply line. Show that the final specific internal energy of the fluid in the tank is equal to h_i. 7

Module -3

15 a) Show the equivalence of Kelvin-Plank and Clausius statements of the second law of thermodynamics. 7

b) A reversible heat engine operates between two reservoirs at temperatures 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 net work output of the combined engine refrigerator plant is 360 kJ. Evaluate the heat transfer to the refrigerant and the net heat transfer to the reservoir at 40°C. 7

16 a) State and prove Clausius inequality. 6

b) One kg of ice. at -5°C is exposed to the atmosphere which is at 20°C. The ice melts and comes into thermal equilibrium with the atmosphere. (a) Determine the 8

entropy increase of the universe. (b) What is the minimum amount of work necessary to convert the water back into ice at -5°C? C_P of ice is 2.093 kJ/kg K and the latent heat of fusion of ice is 333.3 kJ/kg.

Module -4

17 a) Steam initially at 1.5 MPa. 300^{0}C expands reversibly and adiabatically in a steam turbine to 40°C. Determine the ideal work output of the turbine per kg of steam. 7

b) Explain Compressibility factor with respect to Virial expansions. 7

18 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, mass. specific volume, enthalpy, entropy, and internal energy. 8

b) Explain the law of corresponding states. 6

Module -5

19 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 following information is known about the gases in the two vessels. 8

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. If the vessel had been perfectly insulated, calculate the final temperature and pressure which would have been reached. Take $\gamma = 1.4$.

b) Explain Joule Thomson Coefficient and show that Joule Thomson Coefficient is zero for an ideal gas. 6

20 a) Derive Maxwell's relations. 8

b) Explain Dalton's Law of partial pressure, and Amagat's Laws of additive volumes. 6

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