Reg No.:_______________ Name:__________________________

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY

Fourth Semester B.Tech Degree Examination July 2021 (2019 Scheme)

Course Code: MRT202
Course Name: THERMODYNAMICS

Max. Marks: 100 Duration: 3 Hours

PART A

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

1		Differentiate classical and statistical thermodynamics at least on two aspects.	3
2		State the zeroth law of thermodynamics. List a few thermodynamic temperature scales in use.	3
3		What is a thermodynamic work? Describe the work involved in the separation of the gas from the vacuum by a membrane with a neat sketch.	3
4		Define mass and volume flow rates. Explain their relationship with each other.	3
5		What is a thermal energy reservoir? The hot air in a conventional oven be treated as a reservoir of thermal energy for baking some vegetables?	3
6		Consider a heat engine receiving heat at the rate of 90 MW. If the rate of heat rejection is 60 MW, calculate the net power output and thermal efficiency for this heat engine.	3
7		Define a pure substance. When does a uniform mixture of gases can be considered as a pure substance?	3
8		Why the dryness fraction is considered significant in thermodynamics?	3
9		Explain the ways through which the composition of a gas mixture can be well described. The mole and mass fractions for a mixture of CO_2 and N_2O are they identical?	3
10		Explain Joule-Thomson coefficient with respect to throttling process.	3

PART B

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

Module -1

11	a)	What is thermodynamic equilibrium of a system? Explain the necessary conditions required for a system to attain a state of thermodynamic equilibrium.	7
	b)	Explain the working principle of a liquid-in-glass thermometer with a neat sketch.	7
12	a)	What is a thermodynamic property? Explain its types with suitable examples.	7
	b)	Nose bleeding and shortness of breath occurs for some people when they are at high elevations? Explain why?	7

Module -2

13 a) A piston-cylinder device contains 5 kg of air at 30 °C and 300 kPa. It is heated to 350 °C. (i) Verify whether the air can be assumed as an ideal gas for the given conditions, and (ii) calculate the work during the process and (iii) show the process on a T-v diagram. 7

b) A rigid tank contains water at 100 °C and with 90 % quality. The capacity of the tank is 140 litres. If the tank is cooled to –20 °C, then determine the (i) mass of the water and (ii) the heat transfer during the process. 7

14 a) Air enters a diffuser at 100 kPa and 300 K with an inlet velocity of 230 m/s. The area of cross section at the inlet and the exit of the diffuser is 90 mm^2 and 840 mm^2, respectively. If the exit velocity of the air is 25 m/s, determine the (i) exit temperature and (ii) the exit pressure of the air. 7

b) What is an unsteady flow process? Stating the necessary assumptions, derive the expression for the energy equation at any instant of time during the transient process. 7

Module -3

15 a) Consider a reversible heat engine that operates between two reservoirs at temperatures of 900 K and 303 K. This heat engine is designed to drive a reversible refrigerator which operates between two reservoirs at temperatures of 303 K and 253 K. The heat engine receives 2500 kJ of heat. The combined heat engine-refrigerator plant produces a net work output of 410 kJ. Evaluate the (i) heat transfer to the refrigerator and (ii) the net heat rejection to the reservoir which is at 303 K. 7

b) In a steam cycle, 1 kg of mass of the working fluid at 167.77 °C enters the boiler. The specific heat transfers across the boiler and the condenser are accounted to be 2056.98 kJ/kg and –1898.4 kJ/kg, respectively. The temperature of the fluid at the inlet of the condenser is 53.97 °C. Does the steam cycle satisfy the Clausius inequality? 7

16 a) A piston-cylinder device contains 3 kg of water at 200 °C and 10 MPa. With the help of the piston movement, the water undergoes an isothermal expansion process such that the final pressure is 200 kPa. Heat transfer takes place with the surrounding ambient which is at 200 °C. Find the (i) heat transfer and (ii) the total work involved, assuming that the entire process may be reversible. 7

b) A refrigerating unit is used to cool the drinking water from 20 °C to 10 °C. The flow rate of water is 6.95 g/s. If the coefficient of performance of the refrigerator is 3.0 and 7 the surrounding ambient temperature is 25 ° C, then determine the (i) power required to drive the unit, (ii) the rate of irreversibility.

Module -4

17 a) For water, determine whether it is a compressed liquid, superheated vapor, or a mixture of saturated liquid and vapor in each of the following states? Also, calculate the dryness fraction if applicable for water in all these states. (i) 150 ^{0}C, 0.35 m^3/kg, (ii) 20 kPa, 15 ^{0}C, (iii) 1200 kPa, 200 ^{0}C and (iv) 8 MPa, 0.005 m^3/kg. 7

b) Define the compressibility factor. With a neat sketch, explain its significance. 7

18 a) A tank of size 1 m^3 consists of 3 kg of steam at 600 kPa. By using the (i) ideal gas equation, (ii) the Van der Waals equation and (iii) the steam tables, determine the temperature of the steam in Kelvin unit. For steam, take R = 0.4615 kJ/kg K and the Van der Waal's constants: a = 1.705 m^6 kPa/kg^2 and b = 0.00169 m^3/kg. 7

b) (i) Explain the reason why most of the solid regions or compressed liquid are not incorporated in the standard thermodynamic tables in printed format? 7

(ii) It is intended to identify the state of some pure substance. However, the absolute pressure of which is measured to be 150 kPa. In such a situation, explain how realistic it will be to use the equation of state to find the second property?

Module -5

19 a) A mixture of 3 kg of nitrogen and 1 kg of carbon dioxide is contained in a rigid vessel. The mixture is at 303 K and 1.5 MPa. Determine the volume of the tank using the (i) ideal-gas equation of state and (ii) the Amagat's law. 7

b) A mixture of 5 kg of oxygen and 7 kg of nitrogen are at 4 bar and 300 K. For the mixture, find the (i) Mole fraction of each component, (ii) the specific gas constant, and (iii) the partial pressures in kPa and partial volumes in m^3. 7

20 a) In a gas mixture comprising of oxygen and nitrogen, the ratio of mole numbers of nitrogen to oxygen is 3:1. The mixture is subjected to heating in a steady flow process, wherein the temperature was increased from 181 K to 210 K, maintaining the pressure to be constant at 8000 kPa. Using the Kay's rule, find the heat transfer during this process per mole of the mixture. Assume the value of heat transfer as per the ideal gas approximation to be 872 kJ/kmol. 7

b) Derive the first and second forms of entropy equations using the Maxwell's equation. 7

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