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Reg No.:_____ Name:_____

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY

B.Tech Degree S4 (R, S) / S2 (PT) (R, S) Examination June 2023 (2019 scheme)

Course Code: MET202

Course Name: ENGINEERING THERMODYNAMICS

Max. Marks: 100 Duration: 3 Hours

Use of steam tables, Mollier chart and compressibility chart are permitted

PART A

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

1 State the three conditions to be satisfied for a system to be in thermodynamic equilibrium. 3

2 Give the definition and a brief description of the term thermodynamic property of a system. Give the classification of property with exactly one example for each. 3

3 What is a steady flow process? 3

4 Describe the limitations of first law of thermodynamics, with the help of an example case. 3

5 A cyclic heat engine operates between a source temperature of 700^0C and a sink temperature of 28^0C. What is the least rate of heat rejection per KW net output of the engine? 3

6 Why does free expansion have zero work transfer? 3

7 What is the difference between critical point and triple point? 3

8 Give a description on the law of corresponding states. 3

9 Write the ideal gas equation for *n* moles of a gas. Explain each term used in the equation with proper units in SI. How the characteristic gas equation can be obtained from this equation? 3

10 Define Joule-Thomson coefficient. Prove that Joule-Thomson coefficient is zero for an ideal gas. 3

PART B

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

Module -1

11 a) What are meant by a thermometric property and a thermometric substance? Enlist any four types of thermometers with the thermometric substance and thermometric property used in them. 6

b) Explain the working of constant volume gas thermometer. Explain how a constant volume gas thermometer can be used to measure the correct value of steam point. 8

12 a) Explain the concept of continuum in thermodynamics. How will you define density as a macroscopic property using this concept. 6

b) A temperature scale of certain thermometer is given by the relation $t = a \ln p + b$ where a and b are constants and p is the thermometric property of the fluid in the thermometer. If at the ice point and steam point, the thermometric properties are found to be 1.5 and 7.5 respectively, what will be the temperature corresponding to the thermometric property of 3.5 on Celsius scale? 8

Module -2

13 a) A three-process cycle operating with nitrogen as the working fluid has constant temperature compression at 30^0C with initial pressure 100 kPa. Then the gas undergoes a constant volume heating and then polytropic expansion with 1.35 as index of expansion. The isothermal compression requires -67 kJ/kg of work. Determine 10

1. Pressure, volume, and temperature around the cycle
2. Heat in and out
3. Net work

For Nitrogen gas $c_v = 0.7431$ kJ/kgK

b) Explain the first law of thermodynamics as referred to closed systems undergoing a cyclic change. 4

14 a) A compressor receives carbon dioxide gas at 140 kPa with a specific volume of 0.37 m^3/kg and compresses it to a temperature of 325 K. The work per unit mass for compression is 80 kJ/kg. The gas enters through a 15 cm diameter line with a velocity of 10 m/s and leaves with a velocity of 25 m/s. Determine the heat transfer in kW. Take c_p of CO_2 as 0.846 kJ/kgK. 10

b) Derive an expression for work done in an adiabatic process. 4

Module -3

15 a) Two reversible heat engines operating in series are giving equal amount of work. The total work is 50 kJ. If the reservoirs are 1000 K and 250 K, find the intermediate temperature and the efficiency of each engine. Also, find the heat extracted from the source. 10

b) Determine the temperature ratio $\left(\frac{T_2}{T_1}\right)$ (where T_2 = source temperature and T_1 = sink temperature) for a Carnot refrigerator whose COP is 5. If the cycle is used as heat pump, find the COP for heating cycle. 4

16 a) Define the term 'Entropy'. Derive an expression for change of entropy for an isothermal process. 7

b) 5 kg of air at 550 K and 4 bar is enclosed in a closed vessel. Determine the availability of the system if the surrounding pressure and temperature are 1 bar and 290 K respectively. 7

Module -4

17 a) A rigid closed tank of volume 3 m^3 Contains 5 kg of wet steam at a pressure of 200 kPa. The tank is heated until the steam becomes dry saturated. Determine final pressure and heat transfer to the tank. 9

b) Consider the cases of vaporisation of saturated liquid to a saturated vapour at pressure of 100 kPa and 500 kPa. Which case requires more energy? Explain with enthalpy – temperature plots. 5

18 a) Explain the significance of Vander walls equation and its limitations 6

b) A 5 m^3 tank contains 1.0 kmol of an ideal gas at 400 kPa with a molar weight of 31 kg/kmol. 8

i. Determine the gas temperature.

ii. Gas is removed from the tank, temperature remaining constant, until the pressure decreases to 100 kPa. What mass of gas was removed?

Module -5

19 a) Give the statement of Amagat's Law of partial volume for analysis of gas mixtures. Clearly define the terms used in the statements. Write the mathematical equation. 5

b) The products of combustion from a diesel engine have the following molal analysis: CO_2 = 10.2%, CO = 0.4%, H_2O = 14.3%, O_2 = 1.9% and N_2 = 73.2%. Determine the mass fraction of each component. What is the molar mass of the mixture? 9

20 a) Derive energy equation in the form $du = c_v dT + \left\{ T\left(\frac{\partial p}{\partial T}\right)_v - p \right\} dv$ 8

b) A gas obeys $p(v-b) = RT$, where b is a positive constant. Find the expression for its Joule-Thomson coefficient. Can this gas be cooled effectively by throttling? 6

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