Reg No.:_____ Name:_____

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY

THIRD SEMESTER B.TECH DEGREE EXAMINATION, APRIL 2018

Course Code: ME205

Course Name: THERMODYNAMICS (AN, MA, ME, MP)

(Permitted to use Steam tables and Mollier charts)

Max. Marks: 100 Duration: 3 Hours

PART A

Answer any three full questions, each carries 10 marks Marks

1 a) How the Zeroth law of Thermodynamics forms the basis for the measurement of temperature? (4)

b) How the state function varies from path functions with one example each? (6)

2 a) Draw the isochoric, isobaric, isothermal, adiabatic and polytropic processes in a single P-v diagram. Give reason for the shape of each process (6)

b) What is a quasi-static process? Is it a reversible process? How? (4)

3 a) How the First Law of Thermodynamics is applied to a process? Show how this formulation changes when it completes a thermodynamic cycle. (6)

b) 1 kg of air at 4 bar and 150°C is contained in a system. It is expanded by a reversible process till the pressure falls to 1.01325 bar. The gas is then heated at constant pressure process until the heat content is increased by 72.5 kJ. Calculate: (4)

i) The work done

ii) The pressure and temperature at the end of the constant pressure process

iii) The index of expansion, if the above processes are replaced by a single reversible polytropic process giving the same work between the same initial and final states.

Take Cp = 1 kJ/kg K, Cv = 0.714 kJ/kg K.

4 a) Deduce the Steady Flow Energy Equation (SFEE) applied to a steam turbine. (4)

b) 10kg of air per minute is delivered by a centrifugal air compressor. The inlet and outlet conditions of air are C_1 = 12 m/s, p_1 = 1 bar, v_1 = 0.5 m^3/kg and C_2 = 90 m/s, p_2 = 8 bar, v_2 = 0.15 m^3/kg. The increase in enthalpy of air passing through the compressor is 250 kJ/kg and heat loss to the surroundings is 900 kJ/min. Find (6)

i) Motor power required to drive the compressor;

ii) Ratio of inlet to outlet pipe diameter.

Assume that inlet and discharge lines are at 1.5 m height difference.

PART B

Answer any three full questions, each carries 10 marks

5 a) Compare the COP of heat pump to that of a refrigerator. What is the reason for their difference. (4)

b) Explain the internal and external irreversibility with practical examples. (6)

6 a) Explain the working of a Carnot cycle using P-v and T-s diagrams. State why a Carnot engine can't be realised? (6)

b) An inventor claims that he developed a refrigerator for removing a heat of 1440 kJ/min from a temperature of 0°C to 25°C by receiving an external work of 2 kW. Comment on his claim. (4)

7 a) Explain the term availability function. For a non-flow process. (4)

b) In a power station,water enters the boiler at saturated condition and leaves as saturated steam the saturated steam at 200ºC by receiving heat from hot gases in (6)

a steam boiler. Find the increase in total entropy of the combined system of gas and water and increase in unavailable energy due to irreversible heat transfer. Assume that the gases are cooled from 1000°C to 500°C and all the heat from gases goes to water without any losses. Take: cpg (for gas) = 1.005 kJ/kg K, hfg (latent heat of steam at 200°C) = 1940.7 kJ/kg.

8 a) Explain the importance of the critical point during the phase change process of a pure substance usinga P-v diagram. (4)

b) A pressure cooker contains 1.5 kg of saturated steam at 5 bars. Find the quantity of heat that must be removed from the steam so as to reduce the quality steam to 60% dry. What would be the pressure and temperature of the steam at the new state. (6)

PART C

Answer any four full questions, each carries 10 marks

9 a) What are the reasons for the deviation of the real gas behaviour from the ideal gas behaviour. (4)

b) 5 kg of O_2 has a volume of 4.5 m^3 at 110°C. Compute the change in pressure of the gas by using the Van der Waals' equation compared to the ideal gas equation. Assume a = 362850 $Nm^4/(kg\text{-}mol)^2$ and b = 0.0423 m^3/kg-mol. (6)

10 a) State and explain Amagat's law of partial volumes of gas mixtures. (4)

b) A vessel of 0. 5 m^3 capacity contains 0.5 kg of $CO_2$and 1 kg of air at 20°C. Calculate : (6)

i) The apparent molecular mass of the mixture

ii) The partial pressure of each constituent, and

iii) The total pressure in the vessel.

The gravimetric analysis of air is to be taken as 23.3% O_2 and 76.7% N_2

11 a) Derive the first Maxwell's equation from the fundamentals and hence derive the remaining three from the first one. (6)

b) Derivethe law of corresponding state from Vander Waals equation of state. (4)

12 a) Derive the Clausius- Clayperon equation. What is its use? (5)

b) Using Van der Waals equation of state, derive an expression for the change in specific heats at constant pressure and constant volume. (5)

13 a) Explain Joule-Thomson coefficient and Inversion curve. (5)

b) A vessel contains a mixture of 1 mole of CO_2 and 4 moles of airat 1 bar and 20°C. Calculate for the mixture : (5)

i) The masses of CO_2, O_2 and N_2

ii) The percentage carbon content by mass

iii) The apparent molecular weight and the gas constant for the mixture

iv) The specific volume of the mixture.

The volumetric analysis of air can be taken as 21% oxygen and 79% nitrogen.

14 a) What is meant by the term enthalpy of formation? Give reason for the difference between the higher and lower heating values of a fuel. (4)

b) What is equivalence ratio for combustion? Write down the balanced combustion equation with an equivalence ratio of 1.5. (6)

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