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First Semester M.Tech. Degree Examination, June / July 2014
Thermodynamics and Combustion Engineering

Time: 3 hrs.

Max. Marks:100

Note:1. Answer any FIVE full questions.**2. Thermodynamics Data Hand Book is permitted.**

- 1
 - a. Prove that entropy is a property. (06 Marks)
 - b. A gas flows steadily through a rotary compressor. The gas enters the compressor at a temperature of 16°C , a pressure of 100kPa and an enthalpy of 391.2kJ/kg. The gas leaves the compressor at a temperature of 245°C , a pressure of 0.6MPa and an enthalpy of 534.5kJ/kg. There is no heat transfer to or from the gas as it flows through the compressor. Evaluate the external work done per unit mass of gas when the gas velocity at entry is 80m/s and that at exit is 160m/s. (07 Marks)
 - c. 36 gram of water at 30°C are converted into steam at 250°C at constant atmospheric pressure. The specific heat of water is assumed constant at 4.2J/g K and the latent heat of vaporization at 100°C is 2260J/g. For water vapour, assume $pv = mRT$, where $R = 0.4619\text{kJ/kg K}$ and $\frac{C_p}{R} = a + bT + cT^2$, where $a = 3.634$ $b = 1.195 \times 10^{-3} \text{K}^{-1}$ and $c = 0.135 \times 10^{-6} \text{K}^{-2}$. Calculate the entropy change of the system. (07 Marks)
- 2
 - a. Explain available and unavailable energy. (04 Marks)
 - b. Deduce an expression for maximum work in a closed system $W_{\max} = (u_1 - T_0S_1) - (u_2 - T_0S_2)$ with usual notations. (06 Marks)
 - c. In a certain process, while condensing at 420°C transfers heat to water evaporating at 250°C . The resulting steam is used in power cycle which rejects heat at 35°C . What is the fraction of available energy in heat transferred from the process vapour at 420°C that is lost due to the irreversible heat transfer at 250°C ? (10 Marks)
- 3
 - a. Draw and explain P-T diagram for a pure substance. (06 Marks)
 - b. Steam expands isentropically in a nozzle from 1MPa, 250°C to 10kPa. The steam flow rate is 1kg/s. neglecting KE of steam at inlet to the nozzle, find the velocity of steam at exit from the nozzle and exit area of the nozzle. (07 Marks)
 - c. A vessel of volume 0.04m^3 contains mixture of saturated water and saturated steam at a temperature of 250°C . The mass of the liquid present is 9kg. Find the pressure of the mass, the specific volume, the enthalpy the entropy and the internal energy. (07 Marks)
- 4
 - a. Explain Gibbs phase rule with equation. (06 Marks)
 - b. Derive an equation $\left[\frac{\partial C_p}{\partial P}\right]_T = -T\left[\frac{\partial^2 V}{\partial T^2}\right]_P$, with usual notations. (06 Marks)
 - c. Explain types of equilibrium and conditions for same with figure. (08 Marks)
- 5
 - a. Derive an expression for entropy of various mixtures. (08 Marks)

- b. A mixture of ideal gases consists of 3kg of nitrogen and 5kg of carbon dioxide at a pressure of 300kPa and a temperature of 20⁰C. Find i) the mole fraction of each constituent ii) the equivalent molecular of the mixture iii) the equivalent gas mixture iv) partial pressures and partial volumes v) the volume and density of the gas mixture and vi) the Cp and Cv of the mixture.

If the mixture is heated at constant volume to 40⁰C, find the changes in internal energy, enthalpy and entropy of the mixture. Find the changes in internal energy, enthalpy and entropy of mixture if the heating is done at constant pressure. Take γ for CO₂ and N₂ to be 1.286 and 1.4 respectively. (12 Marks)

- 6 a. Define i) Rate of reaction ii) Unilateral reaction iii) Homogeneous reaction iv) Half life. (06 Marks)
- b. Discuss zero order reaction and derive an expression for half life. (06 Marks)
- c. A second order reaction involving reactants with initial concentration of 0.05mol/l found to be 30 percent in 160 sec. Calculate i) The reaction rate constant ii) The half life of the reaction iii) The time would take for the reaction to be 30 percent compute if the initial concentration were 0.005 mol/l. (08 Marks)
- 7 a. Explain cylindrical tube method for the measurement of flame speed and enumerate drawbacks and advantages of cylindrical tube method. (10 Marks)
- b. Explain const volume Bomb method for the determination of flame speed with advantages and disadvantages. (10 Marks)
- 8 a. Explain characteristics stability diagram, with figure for open Burner. (10 Marks)
- b. Explain types of diffusion flames obtained with various flow rates of fuel and air. (10 Marks)
