Seat No.: _____ *Enrolment No._____*

GUJARAT TECHNOLOGICAL UNIVERSITY

M. E. IST Semester–Remedial Examination – July- 2011

Subject code: 712101N

Subject Name: Applied Thermodynamics & Heat Transfer

Date:07/07/2011 **Time: 10:30 am – 01:00 pm**

Total Marks: 70

Instructions:

1. **Attempt all questions.**
2. **Make suitable assumptions wherever necessary.**
3. **Figures to the right indicate full marks.**

Q.1 **(a)** Derive a 3-dimensional general conduction equation in Cartesian co-ordinates for a homogeneous material. Deduce there from an expression for unidirectional unsteady state system when heat is generated within it at the rate of q_g per m^3 of the material. **07**

(b) Explain: Perpetual motion machine of first kind and second kind. Define Kelvin-Planck statement and Clausius statement. Show the equivalence of Kelvin-Planck and Clausius statement. **07**

Q.2 **(a)** Discuss in detail the Joule-Thomson coefficient. **07**

(b) What are the initial and boundary conditions? Explain the different types of boundary conditions applied to heat conduction problems. **07**

OR

(b) Discuss: **07**

i) 'No engine working in a cycle between two constant temperature reservoirs can be more efficient than a reversible engine working between the same two reservoirs.'

ii) 'All reversible engines working between the same temperature reservoirs have the same efficiency.'

Q.3 **(a)** Explain Nusselt number. How it is related to temperature gradient in the fluid immediately in contact with the solid surface? Compare Nusselt number with Biot number. **07**

(b) Show that, with usual notations, the critical radius is given by k/h_o for cylinder for which the heat flow rate is maximum. Also mention the necessary assumptions. **07**

OR

Q.3 **(a)** Discuss how the Clausius inequality provides the criterion for the reversibility of a cycle. **07**

(b) Derive the Maxwell relations and explain their importance in thermodynamics. **07**

Q.4 **(a)** Two rods A and B of the same length and diameter protrude from a surface at 120^0C and are exposed to air at 25^0C. The temperatures measured at the end of the rods are 50^0C and 75^0C. If the thermal conductivity of the material is 20W/m-deg, calculate the thermal conductivity of material B. adopt the condition of a fin insulated at the tip. **07**

(b) Define: black surface, gray surface, real surface, specular reflection, diffused reflection, emissive power, spectral distribution of energy, monochromatic power **07**

OR

Q.4 **(a)** Write Van der Waal's equation. Show that its critical parameters are given by: Vc = 3b, Pc = a/27b^2 and Tc = 8a/27Rb. Hence show that R = 8/3 (PcVc/Tc), b = RTc/8Pc nad a = 27/64 (R^2Tc^2/Pc). Also give the defects of Van der Waal's equation. **07**

(b) Three hollow thin walled cylinders having radii 5 cm, 10 cm and 15 cm are arranged concentrically. The temperatures of the innermost and outermost cylinder surfaces are 1000 K and 300 K respectively. Assuming vacuum between the annular spaces, determine the steady state temperature attained by the cylinder surface having radii of 10 cm. proceed to calculate the heat flow per m^2 area of cylinder with radius 5 cm. take $\epsilon_1 = \epsilon_2 = \epsilon_3 = 0.05$. **07**

Q.5 **(a)** Explain the term absorptivity α, reflectivity ρ and transmissivity τ of radiant energy. How are they related to each other for a black body and an opaque body? Establish the expression and comment on the statement. **07**

$\rho + \alpha + \tau = 1$

(b) Using Maxwell's and other relations, show that **07**

i) $\left(\frac{\partial C_v}{\partial v}\right)_T = T\left(\frac{\partial^2 p}{\partial T^2}\right)_v$

ii) $\left(\frac{\partial C_p}{\partial P}\right)_T = -T\left(\frac{\partial^2 v}{\partial T^2}\right)_p$

iii) $C_p - C_v = T\left(\frac{\partial p}{\partial T}\right)_v \left(\frac{\partial v}{\partial T}\right)_p$

OR

Q.5 **(a)** What is shape factor? Discuss the salient features of the shape factor for analysis of radiant heat exchange between surfaces. **07**

(b) Air at 550 K, 5 kg and 4 bar is enclosed in a closed system. **07**

i) Determine the availability of the system if the surrounding pressure and temperature are 1 bar and 290 K respectively.

ii) If the air is cooled at constant pressure to the atmospheric temperature, determine the availability and effectiveness.

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