Seat No.: ________ Enrolment No.______________

GUJARAT TECHNOLOGICAL UNIVERSITY

M.E. SEMESTER I (old course)–EXAMINATION (Remedial) – WINTER 2015

Subject code: 712101N **Date: 08/12/2015**

Subject Name: Applied Thermodynamics & Heat Transfer

Time: 10:30 AM to 1:00 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) Establish the Clausius Inequality $\oint \frac{\delta Q}{T} \leq 0$. **07**

(b) Write down the expressions for the physical laws that govern each mode of heat transfer, and identify the variables involved in each relations. **07**

Q.2 **(a)** Explain the concept of available energy and unavailable energy. **07**

(b) A heat engine receives heat from a source at 1200 K at a rate of 500 kJ/s and rejects the waste heat to a medium at 300 K. The power output of the heat engine is 180 kW. Determine the reversible power and the irreversibility rate for this process. **07**

OR

(b) A frictionless pistonï cylinder device contains a saturated liquidï vapor mixture of water at 100°C. During a constant-pressure process, 600 kJ of heat is transferred to the surrounding air at 25°C. As a result, part of the water vapor contained in the cylinder condenses. Determine (a) the entropy change of the water and (b) the total entropy generation during this heat transfer process. **07**

Q.3 **(a)** Derive the following Tds equation **07**

$$Tds = c_v \left(\frac{\partial T}{\partial p}\right)_v dP + c_p \left(\frac{\partial T}{\partial v}\right)_p dv$$

and also show that this may be written as:

$$Tds = \frac{c_v}{\beta} K dP + \frac{c_p}{\beta v} dv$$

(b) What is Joule-Thomson coefficient? Why is it zero for an ideal gas? **07**

OR

Q.3 **(a)** Write down the one dimensional transient heat conduction equation for a long cylinder with constant thermal conductivity and heat generation and indicate what each variable represents. **07**

(b) An ordinary egg can be approximated as a 5-cm-diameter sphere. The egg is initially at a uniform temperature of 5°C and is dropped into boiling water at 95°C. Taking the convection heat transfer coefficient to be h =1200 W/m^2-°C, determine how long it will take for the center of the egg to reach 70°C. **07**
Assume following properties for the solution
k= 0.627 W/m · °C and α = 0.151× 10^6 m^2/s

Q.4 **(a)** Derive the governing differential equation for temperature distribution of constant area extended surface in the following form: **07**

$$\frac{d^2\theta}{dx^2} = m^2\theta, Where\ m = \sqrt{\frac{hP}{kA_c}}$$

(b) What are Heisler charts? Explain the significance of Heisler charts in solving transient conduction problems. **07**

OR

Q.4 **(a)** Define Lambertôs cosine law of radiation and prove that the intensity of **07**

radiation is always constant at any angle of emission for a diffused surface.

(b) A black body of 0.2 m^2 area has an effective temperature of 800 K. Calculate (a) the total rate of energy emission (b) the intensity of normal radiation (c) the intensity of radiation along a direction 60° to the normal and (d) the wavelength of maximum monochromatic emissive power. **07**

Q.5 **(a)** Define the Nusselt number. How it is related to temperature gradient in the fluid immediately in contact with the solid surface? Mention various approaches which have been suggested for estimating the value of Nusselt number. **07**

(b) Engine oil at 60°C flows over the upper surface of a 5-m-long flat plate whose temperature is 20°C with a velocity of 2 m/s. Determine the total drag force and the rate of heat transfer per unit width of the entire plate. **07**

OR

Q.5 **(a)** How is Reynolds analogy expressed? What is the value of it? What are its limitations? **07**

(b) Derive the following two dimensional force or momentum equation of the boundary layer with constant properties **07**

$$u\frac{\partial u}{\partial x} + v\frac{du}{dy} = v\frac{d^2u}{dy^2}$$

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