Code Number :.....

HEAT TRANSFER QUALIFYING EXAM

August 2004

OPEN BOOK (only one book allowed) & CLOSED NOTES

Answer all four questions

All questions have equal weight

TIME: 3.0 hrs

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- **Take any required property from your book, approximate values if necessary.**
- **If you make any assumption to reach a solution state it clearly**

Question # 1

A steel sphere with a diameter of 7.6cm is to be hardened by first heating it to a uniform temperature of 870°C and then quenching it in a large bath of water at a temperature of 38°C. For steel, thermal conductivity is 43 W/m K, specific heat is 628 J/Kg K, and density is 7840 kg/m^3. The heat transfer coefficient at the surface of sphere is 590 W/m^{2}K. For this sphere:

(a) Calculate the time required for the center of the sphere to reach to 204°C.
(b) Calculate the time required for the surface temperature to reach to 204°C.
(c) Do you expect more uniform or less uniform temperature distribution inside the sphere with an increase in thermal conductivity? What would be the effect of surface heat transfer coefficient on temperature distribution? Explain (both mathematically and physically).

Question # 2

Water is to be heated from 10 °C to 80 °C as it flows through a 2 cm diameter, 7 m long pipe. The tube is equipped with an electric resistance heater that provides uniform heating throughout the surface of the tube. The outer surface of the tube is well insulated. If the system is to provide hot water at a rate of 8 L/min. Answer the following questions:

(a) What is the Reynolds number?
(b) What is the power rating of the resistance heater?
(c) Estimate the inside surface temperature of the pipe at the exit.
(d) Draw a plot of surface temperature and bulk fluid temperature versus distance down the pipe for this flow.

Question # 3

Consider two very large parallel plates with diffuse, grey surfaces. The top surface is at T = 1000K and has an emissivity of 1. The bottom plate has a temperature of 500K and an emissivity of 0.8.

(a) Determine the irradiation and radiosity for the top surface.
(b) Determine the radiosity of the lower surface.
(c) What is the net radiation exchange between the plates?
(d) Draw the network diagram for this exchange process.

Question # 4

For the wall section of a gas furnace heater, answer the following questions by assuming that: the convection heat transfer coefficient at the interior surface is 15 W/m^2 K; the rate of heat transfer by radiation from hot gases and soot particles at 2000°C to the interior wall surface is 45000 W/m^2; the unit thermal conductance of the wall is 250 W/m^2 K (interior surface temperature is about 850°C); there is convection from the outer surface.

(a) Draw the thermal circuit.
(b) Determine the rate of heat transfer per unit area.
(c) Estimate the exterior surface temperature.