

I. 30 points

A 50 mm diameter sphere made of pure copper has an external wall temperature of 40°C. It is suspended (immersed) in a large unstirred (static) beaker of water with bulk temperature of 20°C. Estimate the heat transfer coefficient for the sphere in the beaker of water.

II. 30 points

A 50 mm diameter sphere made of pure copper initially at 50°C is dipped into a large unstirred (static) beaker of water with bulk temperature of 20°C so that it becomes completely immersed in the water. How long does it take for the center of the copper sphere to reach 30°C? State your assumptions.

III. 40 points

1.0 kg/s of water flows in the inside tube of a double-pipe heat exchanger and is heated from $T_{c,in} = 40$ to $T_{c,out} = 100^\circ\text{C}$ by hot oil (Dowtherm A, pg 646-647 of Hagen) which flows in the outside tube at 3.0 kg/s. The oil enters at $T_{h,in} = 200^\circ\text{C}$. Assume that $U_o = 345 \text{ W/m}^2\text{-K}$ for all calculations.

A. 10 points

Use an energy balance to determine $T_{h,out}$, the exiting temperature of the oil.

B. 20 points

Find the required heat exchanger area A_o , assuming the flows are counter-current.

C. 10 points

Find the required heat exchanger area A_o , assuming the flows are co-current.