

1. A furnace wall consists of 200-mm-thick firebrick ($k = 1.52 \text{ W/m}\cdot\text{K}$) on the flame side, clad with 6-mm-thick steel ($k = 45 \text{ W/m}\cdot\text{K}$) on the outside. The hot side temperature is 1150°C and the cold side surface is at 30°C . A very accurate measurement of heat flow shows that the steady heat flux through the wall is 826 W/m^2 . It is suspected that the steel cladding has separated from the firebrick, leaving a thin layer of air ($k = 0.0277 \text{ W/m}\cdot\text{K}$) to separate these two materials. Is it true? If so, what is the air film thickness? (15%)
2. A silicon wafer with a diameter of 150 mm and thickness of 1mm is initially at a uniform temperature of 800 K. It is suddenly transferred to an evacuated chamber that surrounds completely the wafer. The chamber surface has an emissivity $\epsilon = 0.9$ and is maintained at a temperature of 300 K. The physical properties of the wafer are given as: $\rho = 2300 \text{ kg/m}^3$, $k = 15 \text{ W/m}\cdot\text{K}$, $c_p = 700 \text{ J/kg}\cdot\text{K}$, and $\epsilon = 0.6$. How long does it take to cool the wafer to 350 K? (15%)

3. (15%) Answer the following questions

- (a) A system undergoes a process between two fixed states first in a reversible manner and then in an irreversible manner. For which case is the entropy change greater? Why?
- (b) The entropy of a hot baked potato decreases as it cools. Is this a violation of the increase of entropy principle? Explain.
- (c) Is it possible for the entropy change of a closed system to be zero during an irreversible process? Explain.

4. (20%)

An insulated rigid tank is divided into two equal parts by a partition. Initially, one part contains 5 kmol of an ideal gas of nitrogen (N_2) at 400 Kpa and 50°C , and the other side is evacuated. The partition is now removed, and the gas fills the entire tank. Determine the total entropy change (KJ/K) during this process.

5. (20%)

- (a) Plot the Psychrometric chart of air-water vapor mixtures indicating constant lines of humidity ratio, enthalpy/dry air, relative humidity, dry and wet bulb temperature.
- (b) Sketch a heating process with no change in the moisture content of the air-water vapor mixture on the Psychrometric chart.
- (c) Explain the adiabatic saturation process, and sketch it on the Psychrometric chart.
- (d) A dehumidification process removes water vapor from air by cooling it below its dew point. Sketch this process on the Psychrometric chart.

6. (15%)

- (a) What is the combined gas-steam power cycle? Show its arrangement.
- (b) Explain the combined gas-steam power cycle by using T-s diagram.