ASSIGNMENT #11

Black / Gray Body Radiation Problems

11–1 Two concentric spheres 0.2 m and 0.3 m in diameter are to be used to store liquid air (133 K). The space between the spheres is evacuated. If the surfaces of the spheres have been flashed with aluminum and the liquid air has a latent heat of vaporization of 209 kJ/kg, determine the number of kilograms of liquid air evaporated per hour.

11–2 Determine the steady-state temperatures of two radiation shields placed in the evacuated space between two infinite planes at temperatures of 555 K and 278 K. The emissivity of all surfaces is 0.8.

11– 3 A 1-m × 1-m square solar collector is placed on the roof of a house. The collector receives a solar radiation flux of 800 W/m^2. Assuming that the surroundings act as a blackbody at an effective sky temperature of 30°C, calculate the equilibrium temperature of the collector (a) assuming its surface is black and that conduction and convection are negligible, and (b) assuming that the collector is horizontal and loses heat by natural convection.

11–4 A thin layer of water is placed in a pan 1 m in diameter in the desert. The upper surface is exposed to 300 K air, and the convection heat transfer coefficient between the upper surface of the water and the air is estimated to be 10 W/m^2 K. The effective sky temperature depends on atmospheric conditions and is often assumed to be 0 K for a clear night and 200 K for a cloudy night. Calculate the equilibrium temperature of the water on a clear night and a cloudy night.

11– 5 A 6-mm-thick sheet of polished 304 stainless steel is suspended in a comparatively large vacuum-drying oven with black walls. The dimensions of the sheet are 30 cm × 30 cm, and its specific heat is 565 J/kg K. If the walls of the oven are uniformly at 150°C and the metal is to be heated from 10 to 120°C, estimate how long the sheet should be left in the oven if (a) heat transfer by convection can be neglected, and (b) the heat transfer coefficient is 3 W/m^2K.