1.15 Heating and quenching of a sphere ★★

A sphere, initially at a homogeneous temperature of 25 °C, is put into an oven. The oven temperature remainst constant at a homogeneous temperature of 200 °C. The heat transfer coefficient for this process is 110 W/m²K.

a) Determine the temperature of the center T_m after 3 minutes.

After some time the sphere has a homogeneous temperature of 150 °C and is being quenched. During this process, the ambient temperature remains constant at 30 °C. It was found that after time t_1 the center of the sphere has a temperature of 54 °C and the surface has a temperature of 44.4 °C.

b) Determine the time t_1 it takes for the center of the sphere to have a temperature of 54 °C and the surface to have a temperature of 44.4 °C.

c) Determine the amount of heat dissipated Q at time instant t_1.

Hints

- Heat radiation can be neglected.

- It alwains remains that Fo > 0.2

Given parameter

- Radius of the sphere: $r_1 = 1.5$ cm

- Thermal diffusivity of the sphere: $a = 9.5 \cdot 10^{-7}$ m²/s

- Thermal conductivity of the sphere: $\lambda = 1.52$ W/mK

- Density the sphere: $\rho = 1.45 \cdot 10^3$ kg/m³

- Specific heat capacity the sphere: $c_\mathrm{p} = 0.88$ kJ/kg·K