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/m^{2}K.

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

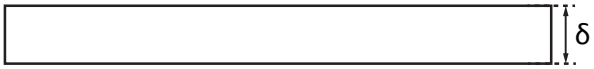
- Heat radiation can be neglected.
- It alwains remains that Fo > 0.2

Given parameter

- Radius of the sphere: $r_1 = 1.5$ cm
- Thermal diffusivity of the sphere: $a = 9.5 \cdot 10^{-7}$ m^2/s
- Thermal conductivity of the sphere: $\lambda = 1.52$ W/mK
- Density the sphere: $\rho = 1.45 \cdot 10^3$ kg/m^3
- Specific heat capacity the sphere: $c_\mathrm{p} = 0.88$ kJ/kg $\cdot$ K

Pizza stone

To improve the taste of a deep frozen pizza, you decided to try a pizza stone. To get the ideal pizza base, the stone has to have a surface temperature of $T_{\mathrm{P,O}}$ and a core temperature of $T_{\mathrm{P,m}}$. Determine the time to heat up the pizza stone, if the stone is placed in the oven at time $t_0 = 0\ s$ with the temperature T_{R}.



Hints

- The lateral surface of the pizza stone is adiabatic
- $\mathrm{Fo} > 0.2$
- The oven has a constant homogeneous temperature T_{O}
- Heat radiation can be neglected.

Given parameter

- Thickness of the pizza stone: $\delta = 5$ cm
- Oven temperature: $T_{\mathrm{O}} = 250$ °C
- Thermal diffusivity: $a = 5.8 \cdot 10^{-7}$ m^2/s
- Surface temperature of the pizza stone: $T_{\mathrm{P,O}} = 205$ °C
- Core temperature of the pizza stone: $T_{\mathrm{P,m}} = 181$ °C
- Temperature of the pizza stone before heating: $T_{\mathrm{R}} = 20$ °C