

Question #79207

The heat transfer from a 2 m diameter sphere to a 25 °C air stream over a time interval of one hour is 3000 kJ. Estimate the surface temperature of the sphere if the heat transfer coefficient is 10 W/m²K

Answer:

The convective heat transfer ($Q = 3000 \text{ kJ} = 3000000 \text{ J}$) is given by:

$$Q = hA(T_w - T_f)\tau, \quad (1)$$

where $h = 10 \text{ W/m}^2\text{K}$ is the heat transfer coefficient,

$$A = \pi d^2 \quad (2)$$

is the surface area of the sphere,

$d = 2 \text{ m}$ is the diameter of the sphere,

T_w is the surface temperature,

$T_f = 25^\circ\text{C}$ is the temperature of the air,

$\tau = 1 \text{ hr} = 3600 \text{ s}$ is the period of time.

So, we can derive T_w from (1) as follow:

$$T_w = T_f + \frac{Q}{hA\tau}, \quad (3)$$

Substitute into (2) and (3):

$$A = \pi \cdot 2^2 = 12.566 \text{ m}^2,$$
$$T_w = 25 + \frac{3000000}{10 \cdot 12.566 \cdot 3600} = 31.6^\circ\text{C}.$$