Question #77400

a 25.5 g silver ring is heated to a temperature of 84 and then placed in a calorimeter containing 5.00 x10^-2 kg of water at 24. the calorimeter is not perfectly insulated, however, and .140 kj of energy is transferred to the surroundings before a final temperature is reached. what is the final temperature?

Solution

By the zeroth law of thermodynamics system of ring and volume of water will reach the thermal equilibrium, which is characterized by the t_0 temperature. Silver ring is hotter, than water, so it will give Q_1 j. of heat energy to the volume of water. At the same time water is colder, than ring, so it will get Q_2 j. of heat energy from ring. But Q_0 j. of heat energy will be transferred to the surroundings, so the final equation is $Q_1 = Q_2 - Q_0$.

$$Q_1 = c_1 m_1 (t_1 - t_0)$$

$$Q_2 = c_2 m_2 (t_0 - t_2)$$

$$c_1 m_1 (t_1 - t_0) = c_2 m_2 (t_0 - t_2) - Q_0$$

$$c_1 m_1 t_1 - c_1 m_1 t_0 = c_2 m_2 t_0 - c_2 m_2 t_2 - Q_0$$

$$c_1 m_1 t_1 + c_2 m_2 t_2 - Q_0 = c_1 m_1 t_0 + c_2 m_2 t_0$$

$$t_0 (c_1 m_1 + c_2 m_2) = c_1 m_1 t_1 + c_2 m_2 t_2 - Q_0$$

$$t_0 = \frac{c_1 m_1 t_1 + c_2 m_2 t_2 - Q_0}{c_1 m_1 + c_2 m_2}$$

$$c_1 = 250\ \frac{j}{kg\ ^\circ\text{C}};\ c_2 = 4200\ \frac{j}{kg\ ^\circ\text{C}};\ m_1 = 25.5 \times 10^{-3}\ kg;\ m_2 = 5 \times 10^{-2}\ kg;\ t_1 = 84\ ^\circ\text{C};$$

$$t_2 = 24\ ^\circ\text{C};\ Q_0 = 0.14 \times 10^3\ j.$$

$$t_0 = \frac{250 \times 25.5 \times 10^{-3} \times 84 + 4200 \times 5 \times 10^{-2} \times 24 - 0.14 \times 10^3}{250 \times 25.5 \times 10^{-3} + 4200 \times 5 \times 10^{-2}}$$

$$t_0 = \frac{535.5 + 5040 - 140}{6.375 + 210} = \frac{5435}{216.375} \approx 25.12\ ^\circ\text{C}$$

Answer

Final temperature is $t_0 \approx 25.12\ ^\circ\text{C}$