Answer on Question #49798, Physics, Molecular Physics

A 1.5 kW hotplate is used to heat 250ml of water in a 292.1g glass beaker both the water and the glass beaker are initially at 20.5C the hotplate is used for 5.5 minutes and produces 495kJ of energy when used. Determine the final temperature of the glass beaker .

Solution

According to the law of conservation of energy, the energy "produced" by hotplate was used to heat water and glass beaker.

$$Q = Q_W + Q_G, \tag{1}$$

where Q is the energy "produced" by hotplate ; Q_W is the energy used to heat water; Q_G is the energy used to heat the glass beaker.

If the water is heated to 100 ° C, it starts boiling. We find the amount of heat required to heat the water from 20.5 to 100 ° C (see Eq. (2))

$$Q_W = c_W m_W (t - t_0), \tag{2}$$

where t the final temperature of water; t_0 the initial temperature of water; c_W is the specific heat of water ($c_W = 4200 J/(kg \cdot C)$); m_W is the mass of water ($m_W = V\rho$); ρ is the density of water ($\rho = 1000 kg/m^3$); V is the volume of water ($250ml = 0.250l = 2.5 \cdot 10^{-4} m^3$).

$$Q_W = c_W m_W (t - t_0) = 4200 J/(kg \cdot C) \cdot 1000 kg/m^3 \cdot 2.5 \cdot 10^{-4} m^3 (100 - 20.5) = 83475 J = 83.475 kJ$$

$$Q_G = c_G m_G (t - t_0), \tag{3}$$

where t the final temperature of the glass beaker; t_0 the initial temperature of the glass beaker; c_G is the specific heat of the glass ($c_G = 840 J/(kg \cdot C)$).

$$Q_G = c_G m_G (t - t_0) = 840 J/(kg \cdot C) \cdot 0.2921 kg \cdot (100 - 20.5) = 19506.4 J = 19.5064 kJ$$

It is clear that $Q = Q_W + Q_G$, $Q_W + Q_G = 102.981 kJ$, $Q = 495 kJ$

The water will be converted into steam. The heat required to convert 250ml of water entirely in steam (see Eq. (4)).

$$Q_S = m_W L \tag{4}$$

L is the specific heat of vaporization ($L = 2256 kJ/kg$).

$$Q_S = m_W L = 1000kg/m^3 \cdot 2.5 \cdot 10^{-4} m^3 \cdot 2256kJ/kg = 564kJ$$

It is clear that $Q_S > \left(Q - \left(Q_W + Q_G\right)\right)$.

Not all water is transformed into steam. During the evaporation temperature of the system will remain unchanged (100 ° C)

Answer: the temperature of the glass beaker will be $100C$