Answer on Question 79559, Physics, Other

Question:

1) A 100 kW electric heater heats up 100 L of water at 20℃ for 2 minutes. If 1 L of water has a mass of 1 kg find the final temperature of water. Specific heat capacity of water is 4200 $J/kg \cdot ℃$.

Solution:

Let's first find the quantity of heat that the water needs in order to reach the final temperature during 2 minutes:

$$Q = mc\Delta t = mc\left(T_{final} - T_{initial}\right),$$

here, $m = 100\ kg$ is the mass of the water, $c = 4200\ J/kg \cdot ℃$ is the specific heat capacity of the water, $T_{initial} = 20℃$ is the initial temperature of the water and T_{final} is the final temperature of the water.

From the other hand, we can write:

$$Q = Pt,$$

here, Q is the quantity of heat that the water needs in order to reach the final temperature during time $t = 2\ min$ and $P = 100\ kW$ is the power of the electric heater.

Finally, we can equate both expressions and find the final temperature of the water:

$$mc\left(T_{final} - T_{initial}\right) = Pt,$$

$$T_{final} = \frac{Pt}{mc} + T_{initial} = \frac{10^5\ W \cdot 2 \cdot 60\ s}{100\ kg \cdot 4200\ \frac{J}{kg \cdot ℃}} + 20℃ = 48.6℃.$$

Answer:

$T_{final} = 48.6℃$.

2) A store hotplate is rated at 1 kW. How long will it take for 1.5 L (1.5 kg) of water initially at 10℃ to start to boil. Specific heat capacity of water is 4200 $J/kg \cdot ℃$.

Solution:

We can find the quantity of heat that the water needs to start to boil from the formula:

$$Q = mc\Delta t = mc\left(T_{final} - T_{initial}\right),$$

here, $m = 1.5\ kg$ is the mass of the water, $c = 4200\ J/kg \cdot ℃$ is the specific heat capacity of the water, $T_{initial} = 10℃$ is the initial temperature of the water and $T_{final} = 100℃$ is the final temperature of the water.

From the other hand, we can write:

$$Q = Pt,$$

here, Q is the quantity of heat that the water needs to start to boil, $P = 1\ kW$ is the power of the store hotplate and t is the time that the water needs to start to boil.

Finally, we can equate both expressions and find the time that the water needs to start to boil:

$$mc\left(T_{final} - T_{initial}\right) = Pt,$$

$$t = \frac{mc\left(T_{final} - T_{initial}\right)}{P} = \frac{1.5\ kg \cdot 4200\ \frac{J}{kg \cdot ℃} \cdot (100℃ - 10℃)}{10^3\ W} = 567\ s = 9.45\ min.$$

Answer:

$t = 567\ s = 9.45\ min.$