

ELECTROTECHNOLOGY
ELTK1100
QUIZ #4
SOLUTIONS

It takes 98 minutes for a commercial electric kettle to raise the temperature of 22kg of water from 20.°C to boiling (100°C). Find the efficiency of heat transfer if the heater is rated at a voltage of 120V and has a resistance of 9.6Ω?

How much will it cost to boil this water if energy costs 9.584¢/kW•h?

$$P = \frac{V_T^2}{R} = \frac{(120V)^2}{9.6\Omega} = 1500W$$

$$\text{Heat Needed } Q = M C \Delta T = 22\text{kg} * \frac{1000\text{g}}{\text{kg}} * 1 * (100^\circ\text{C} - 20^\circ\text{C}) = 1.76\text{Mcal}$$

$$\text{Heat Produced} = \frac{P t}{4.187} = \frac{1500W * 98\text{min} * \frac{60\text{s}}{\text{min}}}{4.187} = 2.11\text{Mcal}$$

$$\text{Efficiency} = \eta = \frac{Q}{\text{Heat Produced}} * 100\% = \frac{1.76\text{Mcal}}{2.11\text{Mcal}} * 100\% = 83.6\%$$

$$P = 1500W = 1.5kW$$

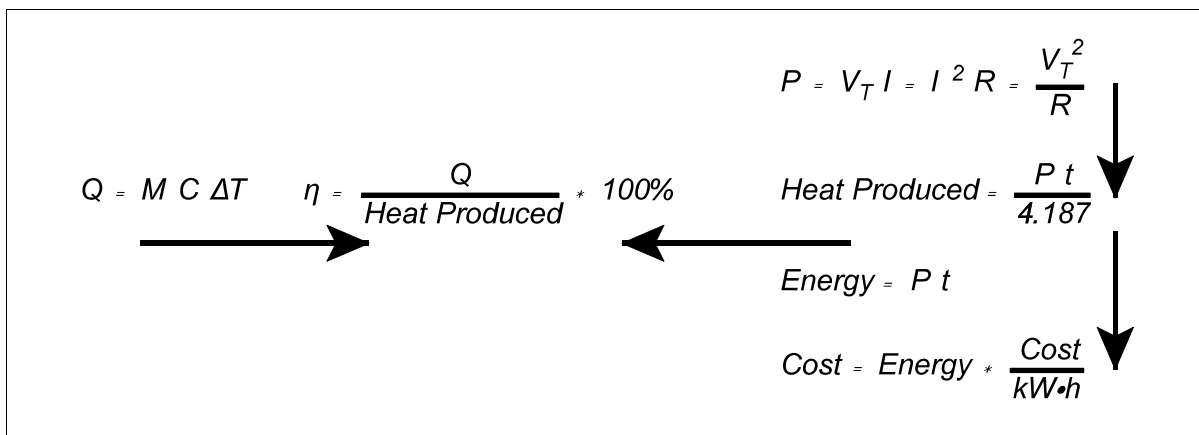
$$t = 98\text{min} = 98\text{min} * \frac{1\text{hr}}{60\text{min}} = 1.633\text{hr}$$

$$\text{Energy} = P t = 1.5kW * 1.633\text{hr} = 2.45\text{kW}\cdot\text{h}$$

$$\text{Cost} = \text{Energy} * \frac{\text{Cost}}{\text{kW}\cdot\text{h}} = 2.45\text{kW}\cdot\text{h} * \frac{\$0.09584}{\text{kW}\cdot\text{h}} = \$0.235$$

Energy costs $\frac{\$0.09584}{\text{kW}\cdot\text{h}}$. ∴ Power must be converted to kW and time to hours because energy must be in kW•h. Only calculation where base units are not used.

In fact, the Cost calculation is a conversion from Energy to Cost.



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A commercial electric kettle is rated at a voltage of 120V and a resistance of 9.6Ω, with an efficiency of 82%. If it takes 92 minutes to boil (100°C) water from room temperature (20.°C), find the mass of the water?

How much will it cost to boil this water if energy costs 9.584¢/kW•h?

$$P = \frac{V_T^2}{R} = \frac{(120V)^2}{9.6\Omega} = 1500W$$

$$\text{Heat Produced} = \frac{P t}{4.187} = \frac{1500W * 92\text{min} * \frac{60s}{\text{min}}}{4.187} = 1.98\text{Mcal}$$

$$Q = \frac{\text{Efficiency}}{100\%} * \text{Heat Produced} = \frac{82\%}{100\%} * 1.98\text{Mcal} = 1.62\text{Mcal}$$

$$M = \frac{Q}{C \Delta T} = \frac{1.62\text{Mcal}}{1 * (100^\circ\text{C} - 20^\circ\text{C})} = 20300g = 20.3kg$$

$$P = 1500W = 1.5kW$$

$$t = 92\text{min} = 92\text{min} * \frac{1hr}{60\text{min}} = 1.533hr$$

$$\text{Energy} = P t = 1.5kW * 1.533hr = 2.3kW\cdot h$$

$$\text{Cost} = \text{Energy} * \frac{\text{Cost}}{kW\cdot h} = 2.3kW\cdot h * \frac{\$0.09584}{kW\cdot h} = \$0.220$$

Energy costs $\frac{\$0.09584}{kW\cdot h}$. ∴ Power must be converted to kW and time to hours because energy must be in kW•h. Only calculation where base units are not used.

In fact, the Cost calculation is a conversion from Energy to Cost.

