Key Concepts

Chapter 3

Power

Energy

Dimensional analysis

Takeaways

This problem essentially tests your understanding of the units for energy and power. Many students think that kWh is a unit of power, not energy, because of the presence of W in the units. These questions become easy points on Test Day when you use dimensional analysis to get the correct answer!

Things to Watch Out For

The relationship between power and energy can be tested in many different scenarios, including electrical circuits, mechanical devices, electrical appliances, or efficiency questions.

Power and Energy

The electricity for a certain industrial-strength space heater costs $1.50 for 40 minutes. The electric company charges 2 cents per kWh. How long would a light with a 100 W lightbulb have to run continuously to use the same amount of energy as the heater uses in 40 minutes?

1) Determine the energy used by the heater.

$$\frac{\$1.50}{(\$0.02/\text{kWh})} = 75\ \text{kWh}$$

A kWh is a unit of energy, because 1 kW = 1 kJ/s, so 1 kWh = 1 (kJ · h/s).

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2) Determine the power of the heater.

$$40\ \text{minutes} = \frac{2}{3}\ \text{hour}$$

$$75\ \text{kWh} = 75\ (\text{kJ}\cdot\text{h/s})$$

$$P = \frac{75(\text{kJ}\cdot\text{h/s})}{\left(\frac{2}{3}\ \text{h}\right)} = 112.5\ \text{kJ/s} = 112.5\ \text{kW}$$

Power is always energy (or work) divided by time, so divide the energy from step 1 by the time. Pay attention to the units here—the time must be in hours!

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3) Determine the time for which the lightbulb could run on the same amount of power.

$$\frac{112.5\ \text{kW}}{100\ \text{W}} = 1{,}125$$

$$\left(\frac{2}{3}\ \text{h}\right) \times 1{,}125 = 750\ \text{h}$$

Divide the power of the heater by the power of the lightbulb. This tells you that the heater uses 1,125 times as much energy every second as the lightbulb does. Then, multiply the time that the heater operated to use 75 kWh of energy by this factor to determine the time for the lightbulb to use that much energy.

Similar Questions

1) How much heat is given off by a 60 W lightbulb in 1 hour if only 99% of the energy is released thermally?
2) How much heat is dissipated in 10 minutes by a 2 kΩ resistor with a current of 25 mA?
3) A certain laser beam delivers 10,000 J of energy to a sample in 5 minutes, and 10% of the laser energy is lost in transit to the sample. What is the power of this laser?