Electrical Power and Efficiency

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Equipment List:

- One small heating appliance for each work group (i.e. – "Hot Shot" water heater, hot plate, microwave ovens of different makes and wattages)
- Temperature probe (or thermometer)
- Stopwatch
- 500 mL room temperature water, divided, per lab group

Physics Van Activity

Name: Date:

Electrical Power and Efficiency

You have already used the equation $\boldsymbol{Q = mC\Delta T}$ to calculate the amount of *energy* required to heat a substance.

And we have previously used the equation $\boldsymbol{E=Pt}$ to determine the amount of electrical energy an appliance of a certain power-rating can supply over time.

Today, you will be putting these concepts together – we will figure out how much energy is required to heat a specified quantity of water, and use that number to determine the amount of time it should take an appliance to heat the water.

Your teacher will assign you to a lab group, and will assign an appliance to each group.

Instructions

1. Obtain 250 mL of room-temperature water from your teacher. Use your temperature probe to determine the temperature of the water. Write down this *initial* temperature below.

$T_{initial}$ = _____

2. If we are going to heat this temperature to boiling, what will its *final* temperature be?

T_{final} = _____

3. Find ΔT, using the numbers you just found. Show your work!

ΔT = _____

4. Since you know the volume of water, you should be able to calculate its mass. Write this mass below:

m_{water} = _____

5. If *C* for water is 4.186 J/g·°C, you can calculate the amount of energy (Q) we would need to heat your water sample to boiling. Don't forget units!!

Q = _____

6. Now determine the power rating for your appliance and write it in the space below.

P = _____

7. We are going to use the equation $E = Pt$ to determine how much time it will take to heat your water sample. Substitute the "Q" from question 5 for the *E* in the equation. How many seconds should it take to heat your water? Check your answer with your instructor and have her initial before you proceed.

Time needed = _____ Instructor's Initials _____

8. Now take the temperature probe out of the water. You are going to use the stopwatch to determine how long the water takes to come to a rolling boil. Rolling boil is defined as bubbles continuously breaking the surface. (NOTE: If you are using the microwave, make sure you have set the cook time for at least 5 minutes, so that it will not stop heating before your water boils!)

9. How much time did it take to heat the water? Does this match your prediction from Questions Number 7?

$t_{required}$ = _____

10. How much energy did you use to heat the water? Use the equation $E = Pt$. "P" is the power rating for your appliance, and "t" is the time you measured in part 9.

E_{used} = _____

11. Is this number larger than, smaller than, or the same as the Q you determined in Question number 5?

The Second Law of Thermodynamics states (roughly) that no engine can convert energy from one form to another without some loss.

12. Does the Second Law of Thermodynamics apply to this experiment?

13. What do you think happened to the "missing" energy?

14. A lot of equipment, appliances, and other things with motors are advertised as "energy-efficient". Using the information you have learned so far in this lab, what do you think energy-efficient means?

15. We can calculate the efficiency of your appliance using the data you found today. Use the following equation to calculate efficiency for your appliance.

$$\text{Efficiency} = \frac{Energy_{out}}{Energy_{in}} \times 100\%$$

Efficiency = _____

16. Your appliance converts one type of energy to another. What is the *original* energy in the form of?

17. What form is this energy converted *to*?

EXTRA CREDIT If your electric company charges $0.083 per kWh, how much did it cost your group to heat your water sample? NO CREDIT unless you show all your work!!