Physical Chemistry I **In Class Problem**

A traveling saleswoman comes to your door and claims that the heat pump she is selling will reduce your home heating bill by at least two-thirds! You are interested, but somewhat skeptical. You invite her in and let her make the pitch.

The heat pump operates with Carnot efficiency and extracts heat from ground water initially at 10°C. The heat is then delivered to your home which you like to keep at a comfortable 25°C, and the colder water is discarded to the drain at essentially 0°C. Electricity is used to drive the heat pump itself and to pump the necessary 10°C-water out of your 50-meter deep well.

You become excited, but you try to muffle your enthusiasm as you nonchalantly glance around the room for your calculator. It's not at your desk where you thought you had left it! Nervously, you offer Ms. Gibbs a cup of coffee which she graciously accepts. You show her into your library and invite her to browse through your collection of rare chemistry books while you go to make the coffee. Once in the kitchen, you find your calculator, your latest electric bill, and, oh yes, the coffee pot.

You start the coffee and sit down at the kitchen table to scratch out some hasty calculations:

a. Calculate the Carnot efficiency, η, for this heat pump (Assume the average temperature of the low-temperature reservoir, the cold water is 5°C).

b. Your electric bill shows that the electric heater that heats your home consumes an average of 10.0 kilowatts of power to maintain a temperature of 25°C in your home throughout the winter. Find the work that must be done on the heat pump every second in order to deliver this 10.0 kw of heat power to your home.

c. Find the quantity of heat that must be extracted from the cold water every second in order to maintain the 10.0 kw of heat flow to the house.

d. What quantity of water at 10°C must be pumped from the ground every second to provide this heat extraction rate? (Assume the temperature of this water drops to 0°C instantaneously).

e. What is the electric power required by the water pump to "lift" this quantity of water out of your 50-meter well.

f. What is the total electric power required by the heat pump-water pump system?

g. The cost of this electricity is $0.0686/kwh. (A kwh (kilowatt-hour) is a unit of energy). Find the cost of heating your home for a 30-day month in the winter by (1) direct electric resistive heat (your current heating system {pun intended}), and (2) the new heat pump.

Coffee is ready. You pour two cups and bring them to the library. What do you tell Ms. Gibbs?