

APES Energy Problems

The Basics:

Energy: The basic unit of energy is a Joule (J). Other units are calorie, kilojoule, British Thermal Unit (BTU), and therm (thermal unit).

1 joule(J) = the force of 1 amp with 1 ohm of resistance

1000J = 1 kJ

1000cal = 1kcal

1 cal = 4.184 J

1 BTU = 1.05 kJ

1 Therm = 100,000 BTUs

Electrical Units

1 watt = 1 joule per second

1 kilowatt(kW) = 1000 watts

1 megawatt(MW) = 1,000,000 watts

1 kilowatt-hour(kWh) = 1000 watts per hour

BTU defined: the amount of energy needed to raise 1 lb. of water 1°F.

Power: Power is the rate at which energy is used. ($P = E/t$) Unit: Watt

$$1W = 1J/s \quad (1Watt = 1 Joule per second)$$

A 100 Watt bulb uses 100 J/sec of electrical energy. If it is 20% efficient, then the bulb converts 20% of the electrical energy into light and 80% is wasted by being transformed into heat (ever felt a hot light bulb?).

What is the example of the First Law of Thermodynamics above?

What is the example of the Second Law of Thermodynamics above?

Some Practice:

1. How much energy, in kJ, does a 75 Watt light bulb use then it is turned on for 25 minutes?

2. The Kilowatt Hour, or kWh, is not a unit of power but of energy. Notice that kilowatt is a unit of power and hour is a unit of time. $E = P \times t$ (rearranged from above). A kilowatt hour is equal to 1 kW delivered continuously for 1 hour (3600 sec).

Assume your electric bill showed you used 1355 kWh over a 30-day period.

- a.) Find the energy used, in kJ, for the 30 day period.
- b.) Find the energy used in J/day.
- c.) At the rate of \$.0749/kwh, what will your electric bill be for this month?

3. A 100 Watt light bulb is 20% efficient.

- a.) How much energy does it use in 12 hours of operation?
- b.) How much energy does the bulb convert to light during 12 hours?
- c.) Convert total energy use to kWh

4. An electric clothes dryer has a power rating of 4000 W. Assume a family does 5 loads of laundry each week for 4 weeks. Assume each dryer load takes 1 hour.

- a.) Find the energy used in J and kWh.
- b.) Find the operating cost for 4 weeks. Assume cost is \$.0758/kWh

5. Refrigeration is costly in terms of energy usage. A single-door, manual defrost refrigerator uses 600 kilowatt hours/year (abbreviated kWh/yr). A large, 20 cu ft two-door automatic defrost refrigerator uses 1880 kWh/yr. How many kcal/yr do each type of refrigerator use? $1\text{kWh} = 860\text{kcal}$.

6. Assume you use an air conditioner for a total of 137 days, 24 hours per day, at a rate of 7.25 kWh per hour. Assume the cost per kWh is **\$.0825** and 1 kWh = 3400 BTUs.

- a.) Calculate the total number of kWh used per year.
- b.) Determine the cost of air conditioning for one year.
- c.) How many kcal are used per year?
- d.) How many BTUs are used in one year?

7. Suppose your electric lights use 400 watts per hour and average four hours per day, every day for one year.

- a.) How many kWh per year does this represent?
- b.) If replacing the lights with a fluorescent bulb would save 60 w per night, what savings in kWh does this represent in one year?
- c.) If the fluorescent bulb costs \$18 but lasts for 10 years, would you consider it a wise investment over incandescent bulbs? Explain your answer.

8. Transportation energy is costly.

- a.) Calculate the gallons of gas use just for going to the supermarket in one year if you take 5 trips to the store per week, traveling 7.5 miles roundtrip, and your car gets 22 miles per gallon.
- b.) Convert the gallons to kcal/year if there are 32000 kcal per gallon.
- c.) What are some of the other energy uses associated with getting foodstuffs to the consumer other than transportation costs?
- d.) What suggestions would you make to the “average American” to help save energy and money relating to the answers you gave in C?

9. (This question is extracted word for word from the 1998 APES exam) The environmental impact of washing a load of dirty dishes in an electric dishwasher differs from that of washing them by hand in a sink. Use the information and data below to answer the questions that follow. Show your calculations.

Assume:

- i. The dishes all fit in one load.
- ii. The water coming into the water heater for the sink and into the water heater in the dishwasher is at 50° F.
- iii. The water heaters for the sink and the dishwasher are both 100% efficient.
- iv. In one complete cycle, the electric dishwasher uses 10 gallons of water heated to 140° F and the dishwasher also uses 0.500 kWh of electrical energy for its mechanical operation.
- v. Washing the dishes by hand requires 20 gallons of water heated to 110° F.

Other Information:

1 gallon of water = 8 lb. water

1 BTU = the amount of energy needed to raise the temperature of 1 pound of water by 1° F.

1 kWh = 3400 BTUs.

a. Calculate the total energy (in BTU's) used both to heat the water and run the electric dishwasher to wash a load of dishes.

b. Calculate the energy (in BTU's) used to heat the water for washing the load of dishes by hand

c. Discuss the economic and environmental costs and benefits of

- i. using the electric dishwasher (including its manufacture and disposal)
- ii. washing the dishes by hand