

Worksheet: Energy and Power for APES**I. The basics:**

A. The basic unit of energy is a Joule (J). $1000\text{J} = 1\text{ kJ}$ Other units of energy are:

$$1\text{ cal} = 4.184\text{J} \quad 1\text{ BTU} = 1.05\text{ kJ} \quad 1\text{ therm} = 100\,000\text{ BTU}$$

B. Power is the rate at which energy is used: $P = \frac{E}{t}$ The unit of power is the watt;

$$1\text{ W} = \frac{1\text{ J}}{\text{s}} \quad (1\text{ watt} = 1\text{ joule per second})$$

Thus a 100 watt light bulb uses 100 J/sec of electrical energy. If it is 20% efficient, then the light bulb converts 20% of the electrical energy into light (the purpose of a light bulb) and 80% of the energy is transformed into heat.

Notice that in the above example we can see the operation of both the First and Second Laws of Thermodynamics. The First says that energy can be changed from one form to another but none is lost. We have accounted for all of the energy, but most of the electrical energy (high quality) has been transformed to low quality energy (heat). Thus we also see the Second Law, that in any energy transformation some energy is lost as heat and is therefore not available to perform useful work.

C. Knowing the relationship between energy and power allows us to find the energy used when an appliance of known power (in watts) operates for a known period of time (in seconds).

Example: How much energy, in kJ, does a 75 watt light bulb use when it is turned on for 25 minutes?

$$\text{Equation: } E = P \times t \quad (\text{rearranging } P = \frac{E}{t})$$

$$\text{Solution: } E = \frac{75\text{ J}}{\text{s}} \times \frac{60\text{ s}}{\text{min}} \times 25\text{ min} = 110\,000\text{ J} = 110\text{ kJ} \quad (2\text{ sig figs})$$

D. If the wattage is not given, then some information about the current can usually be found. To find the power (in watts) of any electrical appliance in your home that does not give the wattage, use the equation $P = VI$ V is the voltage, I is the current in amps (A). American household voltage is 110 V (AC, electric stoves and driers are 220 V).

E. The Kilowatt Hour or kwh is not a unit of power but a unit of energy. Notice that kilowatt is a unit of power and hour is a unit of time. so $E = P \times t$. A kilowatt-hour is equal to 1 kw or 1000 watts delivered continuously for 1 hour (3600 sec)

$$1\text{ kwh} = \frac{1000\text{ J}}{\text{sec}} \times 3600\text{ sec} = 3.6 \times 10^6\text{ J} = 3600\text{ kJ}$$

Example: Lee's Nov-Dec Duke Power bill shows that her home 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 is Lee's Duke Power bill (w/out tax)?

II. Problems: Give an equation, show work with units and give correct answer with units and correct number of sig figs.

1. The current through a toaster (110 V) is 8.0 A. (a) What is the power of the toaster, in W?

answer _____

(b) How much energy, in J, will the toaster use in 5.0 minutes of operation?

answer _____

2. A 100 watt light bulb is 20.0% efficient. (a) How much energy does it use in 12 hours of operation?

ans _____

(b) How much energy does the bulb convert to light during the 12 hours? How much to heat?

to light _____

to heat _____

(c) Convert the total energy use to kwh.

ans _____

3. A electric clothes dryer has a power rating of 4000 W (3 sig figs). Assume that a family does 5 loads of laundry each week for 4 weeks (about a month). Further assume that each dryer load takes 1 hr.

(a) Find the energy used, in J and kwh.

ans _____ J

ans _____ kwh

(b) If the cost of electricity is \$.0758/kwh, find the cost of operating the dryer for 1 month.

ans _____

4. Lee's natural gas bill states that her household used 110 therms of energy for a 30 day period. (a) Using the information on page 1, convert 110 therms to kwh.

ans _____ kwh

(b) Her energy charge for the energy was \$88.78. Find the cost of this gas, in \$/kwh.

ans _____

Which form of energy is more expensive, electricity or natural gas? _____

How many times more \$\$? _____