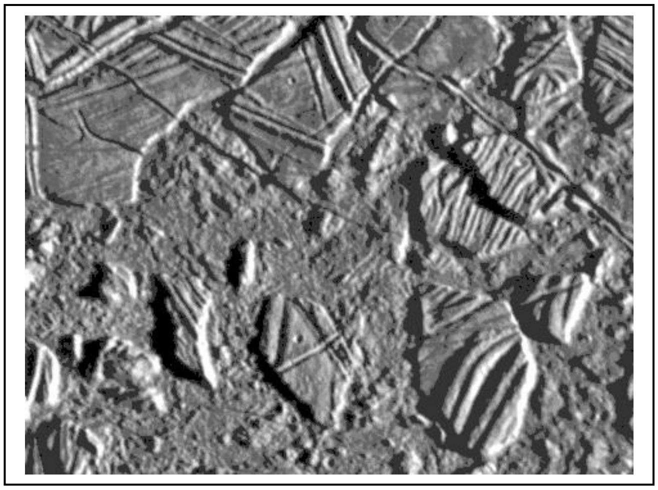
Water on Planetary Surfaces



Space is very cold! Without a source of energy, like a nearby star, water will exist at a temperature at nearly -270 C below zero and frozen solid. To create a permanent body of liquid water in which pre-biotic chemistry can occur, a steady source of energy must flow into the ice to keep it melted and in liquid form. Common sources of energy on Earth are volcanic activity, oceanic vents and fumaroles, and sunlight.

The picture above was taken by NASA's Galileo spacecraft of the surface of Jupiter's moon Europa. Its icy crust is believed to hide a liquid-water ocean beneath. The energy for keeping the water in a liquid state is probably generated by the gravity of Jupiter, which distorts Europa's shape through tidal action. The tidal energy may be enough to keep the oceans liquid for billions of years.

A common measure of energy flow or usage is the Watt. One Watt equals one Joule of energy emitted or consumed in one second.

Problem 1: How much energy, in Joules, does a 100 watt incandescent bulb consume if left on for 1 hour?

Problem 2: A house consumes about 3,000 kilowatts in one hour. How many Joules is this?

Problem 3: A homeowner has a solar panel system that produces 3,600,000 Joules every hour. How many watts of electrical appliances can be run by this system?

Water ice at 0 C requires 330,000 Joules of energy to become liquid for each kilogram of ice. Suppose the ice acted like a battery and absorbed all the energy that fell on it. Ice doesn't really work that way, but let's suppose that it does just to make a simple mathematical model!

Problem 4: A student wants to melt a 10 kilogram block of ice with a 2,000-watt hair dryer. How many seconds will it take to melt the ice block completely? How many minutes?

Answer Key

Problem 1: How much energy, in Joules, does a 100 watt incandescent bulb consume if left on for 1 hour?

Answer: 100 watts is the same as 100 Joules/sec, so if 1 hour = 3600 seconds, the energy consumed is 100 Joules/sec x 3600 seconds = 360,000 Joules.

Problem 2: A house consumes about 3,000 kilowatts in one hour. How many Joules is this?

Answer: 3,000 kilowatts x (1,000 watts/1 kilowatt) = 3,000,000 watts. Since this equals 3,000,000 Joules/sec, in 1 hour (3600 seconds) the consumption is 3,000,000 watts x 3,600 seconds = 10,800,000,000 Joules or 10.8 billion Joules.

Problem 3: A homeowner has a solar panel system that produces 3,600,000 Joules every hour. How many watts of electrical appliances can be run by this system?

Answer: 3,600,000 Joules in 1 hour is an average rate of 3,600,000 Joules/3,600 seconds = 1,000 Joules/sec or 1,000 Watts. This is the maximum rate at which the appliances can consume before exceeding the capacity of the solar system.

Problem 4: A student wants to melt a 10 kilogram block of ice with a 2,000-watt hair dryer. How many seconds will it take to melt the ice block completely? How many minutes?

Answer: From the information provided, it takes 330,000 Joules to melt 1 kilogram of ice. So since the mass of the ice block is 10 kilograms, it will take 330,000 x 10 = 3,300,000 Joules

If the ice stores the energy falling on it from the hair dryer, all we need to do is to calculate how long a 2,000-watt hair dryer needs to be run in order to equal 3,300,000 Joules. This will be Time = 3,300,000 Joules/2000 watts = 1650 seconds or about 27.5 minutes.

Proving that the unit will automatically be in seconds is a good exercise in unit conversions and using the associative law and reciprocals:

1 Joule / (1 watt)	= 1 Joule / (1 Joule/sec)	
	= 1 Joule x (1 sec/1 joule)	: Multiply be the reciprocal
	= (1 Joule x 1 sec)/ 1 joule	: Re-write
	= 1 sec x (1 joule / 1 joule)	: Re-group common terms
	= 1 sec.	:after cancling the 'joules' unit.