

9I Electricity and energy...How electricity transfers energy

lesson

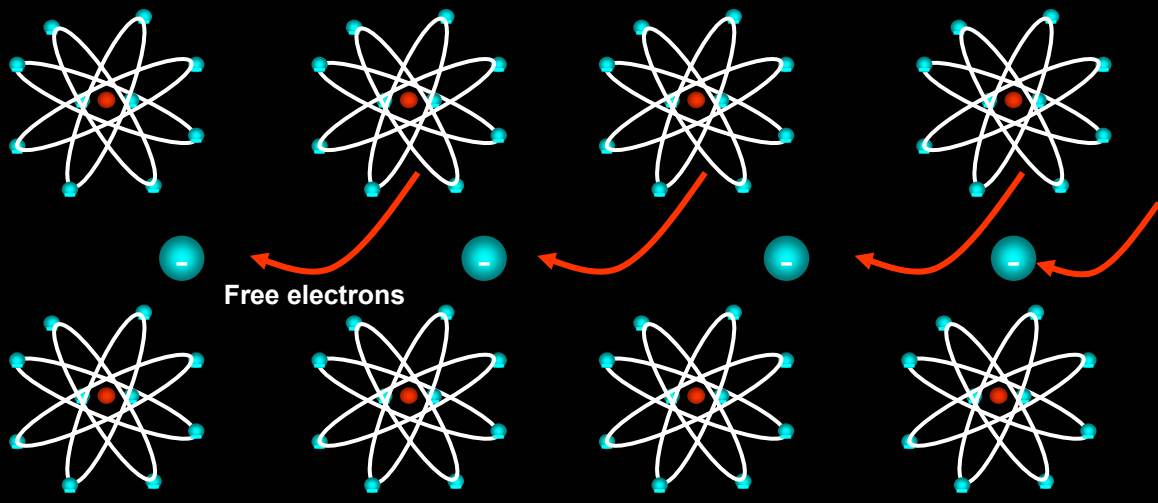

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Using electrical energy

Electrical energy is *cheap, easy to transport, clean at the point of use* and *relatively safe* to use. It is also easily converted into other forms of energy by household devices like bulbs, toasters, televisions and heaters. In a circuit, free electrons move creating a flow of electricity. In a simple circuit, a battery supplies the energy to the moving current so that a device like a bulb or a motor can do useful work. Electrons are not destroyed or used up when they pass through a device, simply the energy they carry is converted into another form of energy.

Energy transfer inside circuits:





	Current flow in a simple circuit	The simple light bulb
Diagram		
Notes	<p>In a light bulb filament, <i>3 billion free electrons</i> flow through the tungsten filament every billionth of a second. These electrons carry electrical energy which is then converted into light and heat energy by the bulb filament.</p>	

Energy transfer in circuits *one*

The rate of transferring energy, called power (watts), is measured in joules per second. A **60 watt light bulb** transforms electrical energy to heat and light at the rate of 60 joules per second. Similarly, a **3 kilowatt heater** transfers electrical energy to heat and light energy at the rate of 3000 joules per second. A simple equation tells us how much electrical energy in joules a device uses over a certain amount of time:

Energy transferred (joules) = Power (watts) x time (seconds)




Energy transfer:

	2 KW kettle	3KW heater	500W plasma light	1.5KW hair dryer
Diagram				
Notes	2 kilojoules of electrical energy are transferred into heat and sound energy by the kettle every second.	3 kilojoules of electrical energy are transferred into heat and light energy by the electric heater every second.	500 joules of electrical energy are transferred into light energy only by the plasma toy every second.	1500 joules of electrical energy are transferred into heat, sound and kinetic energy by the hair dryer every second.

Energy transfer in circuits ^{two}

Electrical energy is **easily converted** into other forms of energy. In a circuit, a flow of electricity carries electrical energy which is then converted into other forms of useful energy by household devices like bulbs, toasters, televisions, laptops and heaters. During energy transformation, some energy is lost to the surroundings, for example a bulb converts electrical energy to heat and light energy. Only the light energy is useful with the heat energy being lost to the surroundings. ***In the following examples, the useful energy is underlined.***

Energy transfer:

Electrical energy in	Device	Energy transformation/energy out
Electrical energy	Kettle 	<u>Heat</u> and sound energy
Electrical energy	Laptop 	<u>Light</u> , <u>sound</u> and heat energy
Electrical energy	Hair dryer 	<u>Heat</u> , <u>kinetic</u> and sound energy

Notes: Consider the kettle. It runs on 2000 watts (2000 joules per second) and transfers 1900 joules per second into heat and the rest into sound energy. This energy transfer can be shown as a diagram.




Energy transfer in circuits *three*

When energy is transformed into another form by a device like a toaster, motor, bulb, buzzer or bell, some useful energy is lost to the environment. The efficiency of a device can be worked out using the following formula.

Energy efficiency = Useful energy out/total input energy x 100 (units %)

Look at the following examples, the useful energy is underlined.




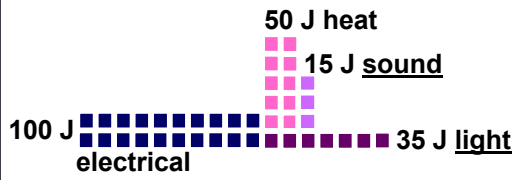
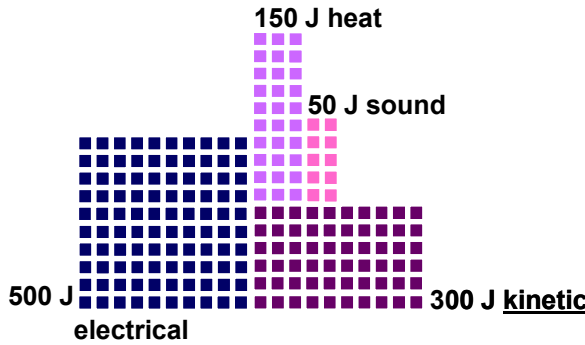
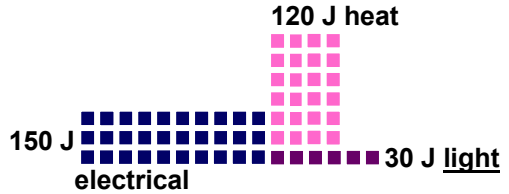
Energy transformations:

Example	Energy in	Device	Useful energy (red)	Energy efficiency
One	12 J of electrical		11 joules of <u>light</u> energy 1 joule of heat energy	Calculation: $11\text{J}/12\text{J} \times 100$ $= 91.6\%$
Two	1000 J of electrical		650 J of <u>heat</u> energy 250 J of <u>kinetic</u> energy 100 J of sound energy	Calculation: $650\text{J} + 250\text{J}/1000\text{J} \times 100$ $= 90\%$
Three	100 kJ of electrical		25 kJ of <u>sound & light</u> energy 75 kJ of heat energy	Work out using the formula, the energy efficiency of a plasma television?

Energy transfer in circuits *four*

Energy transfer diagrams show the relationship between the **input energy** and the **output energy** of a device like a games console, vacuum cleaner and light bulb. During all energy transformations, some energy is lost to the surroundings, for example a vacuum cleaner converts 500 joules of electrical energy to 300 joules of kinetic energy and 200 joules to heat and sound energy. Only the kinetic energy is useful, with the heat and sound energy being lost to the surroundings. *In the following examples, the useful energy is underlined.*

Energy transfer inside circuits:

	Console (100W)	Dyson (500W)	Light bulb (150W)
Diagram			
Transfer Diagram Js ⁻¹	 <p>100 J electrical</p> <p>50 J heat</p> <p>15 J <u>sound</u></p> <p>35 J <u>light</u></p>	 <p>500 J electrical</p> <p>150 J heat</p> <p>50 J sound</p> <p>300 J <u>kinetic</u></p>	 <p>150 J electrical</p> <p>120 J heat</p> <p>30 J <u>light</u></p>
Notes	Every second, a games console converts 50 joules of electrical energy into heat, 15 joules into sound and 25 joules into light. This heat energy is lost to the surroundings.	Every second, a Dyson converts 500 joules of electrical energy into 300 joules of kinetic energy, 50 joules into sound and 150 joules into heat. The heat and sound energy is lost to the surroundings.	Every second, a light bulb converts 120 joules of electrical energy into heat and 30 joules into light energy. The heat energy is lost to the surroundings.