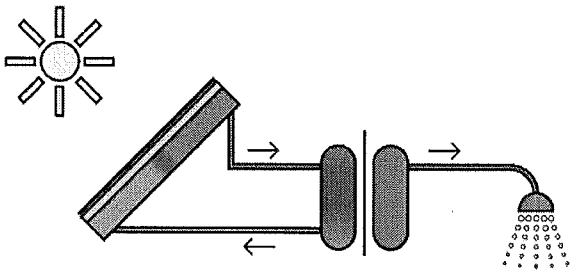
Lesson 8: Heat Energy

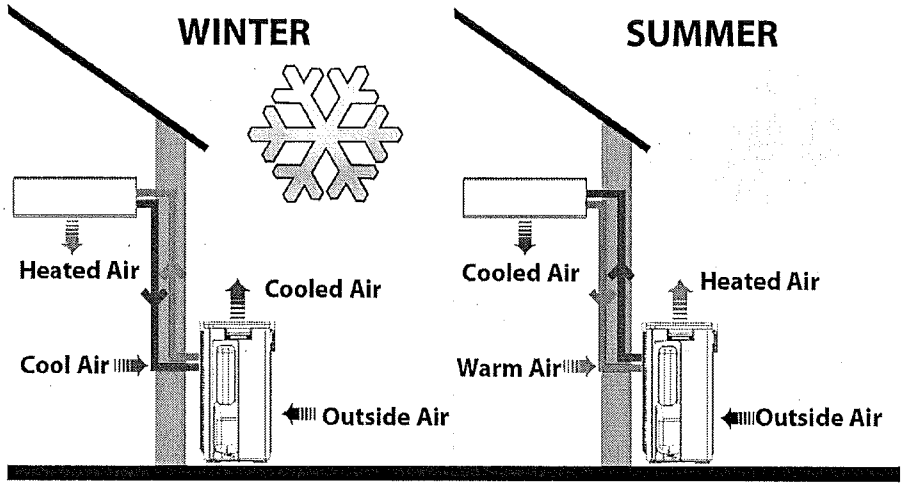


What is Thermal Energy?

Thermal energy is the total energy stored in an object. It is the sum total of all the kinetic and potential energy of the molecules within an object.

Heat energy is the energy that is transferred from one object to another because of a difference in temperature.

How Heat Pumps Work

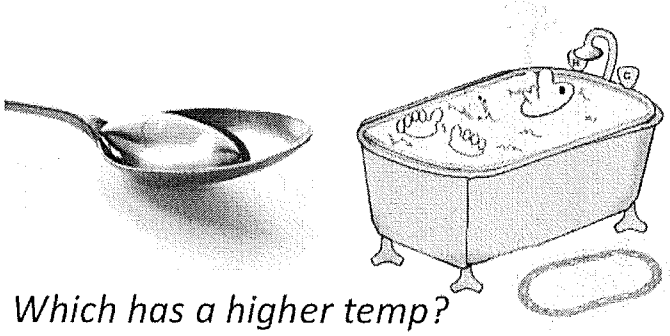


Heat pumps do not generate heat but extract it from one body of air and transfer it to another. They use the same principle as your fridge, compressing gas and then allowing it to expand, extracting heat as it does so.
Even if the air outside is freezing, heat pumps can extract heat energy and transfer it inside to keep you warm. In summer the system works in reverse, extracting heat from indoors and transferring it outside leaving you comfortable and cool.
During The Summer, a heat pump pulls heat from inside your home and moves it outside, just like an air conditioner. During Winter, a heat pump pulls heat from outside and moves it into your home. During extreme cold weather, the heat pump will use a backup heat source.

Which contains more thermal energy?

Temperature is a measure of the average energy per molecule.

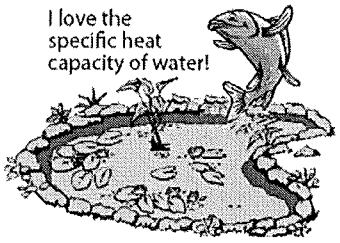
A teaspoon of boiling water or a bathtub full of lukewarm water



Which has a higher temp?

The total amount of heat needed to raise the temperature of an object depends on three quantities:

1. mass of the object
2. desired temperature change
3. the specific heat capacity.



The specific heat capacity (c) is a measure of how much energy (J) is needed to change the temperature of 1kg of mass by one °C. The specific heat capacity for water is 4200J/kg°C.

The total amount of heat energy needed to raise the temperature of an object can be calculated using:

$$\mathbf{\Delta E_h = mc\Delta T}$$

ΔE_h is the heat energy added or lost in joules (J)
m is the mass of the object (kg)
c is the specific heat capacity (J/kg°C)
ΔT is the change in temperature (°C)

Example: How much heat energy does it take to raise the temperature of 100g of lead shot from 20°C to 33°C? The specific heat capacity of lead is 130J/kg°C.

$$\Delta E_h = mc\Delta T$$

$$\Delta E_h = 0.100\text{kg} \times 130\ \text{J/kg°C} \times (33 - 20)\text{°C}$$

$$\Delta E_h = 1.7 \times 10^2\text{J}$$

Additional Practice:
Use the following table to help you answer questions 1-8

Substance	Specific heat capacity (J/kg°C)
Water	4200
Air	990
Copper	390
Iron	450
Concrete	3400
Cotton	1400

1. What are the units for specific heat capacity?

J/Kg °C

2. What is the unit for energy?

Joules

3. How much energy is needed to heat up 1kg of water by 15°C?

$E = mc\Delta T = 1\,kg \times 4200\,J/kg°C \times 15°C$
$= 63{,}000\,J$ or $63\,kJ$

4. How much energy would be needed to raise the temperature of a 5kg block of concrete by 10°C?

$E = mc\Delta T = 5kg \times 3400 \times 10°C = 170{,}000\,J$ or $170\,kJ$

5. Can you calculate the energy needed to increase the temperature of 100kg of iron by 40°C?

$E = mc\Delta T = 100\,kg \times 450 \times 40°C = 1{,}800{,}000\,J$
or $1800\,kJ$

6. A 20kg concrete block is at 20°C and is heated to 65°C. What is the energy used to heat this block?

$E = mc\Delta T$
$= 20kg \times 3400 \times (65-20)$
$= 3{,}060{,}000\,J$ or $3060\,kJ$

7. A 250g copper pipe is heated from 10°C to 31°C. What is the energy needed to heat the pipe?

$E = mc\Delta T = 0.250\,kg \times 390 \times (31-10) = 2048\,J$

8. Can you rearrange the equation to calculate the temperature difference?

$E = mc\Delta T$ thus $\Delta T = \frac{E}{mc}$