

THERMAL ENERGY PROBLEMS

Thermal energy (E_h) is an example of _____ energy, as it is due to the motion of _____, with motion being the key. Thermal energy results in an object or a system having a _____ that can be measured. Thermal energy can be _____ from one object or system to another in the form of _____. Sometimes thermal energy is defined as the total internal energy of all the particles in a body. This would include the translational (_____) kinetic energy that could be detected by a _____, as well as all the energies contained in the _____ and _____ of particles that _____ be detected. This is why a mass can _____ energy and _____ increase its temperature (for example: when melting ice into liquid water, it will take in energy, but _____ change temperature until the liquid has formed, then the temperature will start to rise.)

To calculate the _____ **energy, E_h** , of an object, use the following formula:

Where:

- Mass (m) is measured in _____ (kg)
- Specific heat capacity (C) is measured in joules per kilogram per kelvin (_____)
- Temperature (T) measured in _____ (K)
- E_h is measured in _____ (J)

Note: we use the subscript “h” (from “heat”) for thermal energy because “t” will be used later for “total” energy. It’s not quite right, but will do for now.

It is rare to need to calculate the total thermal energy of an object. Most often we are interested in the increase or decrease of thermal energy. Heat is defined as the change in thermal energy (ΔE_h). Heating refers to an increase in thermal energy and cooling refers to a decrease in thermal energy.

To calculate the _____ in thermal energy (or heat) ΔE_h of an object, use the following formula:

Equation:

The size of one kelvin and the size of one degree Celsius is the _____ on a thermometer, therefore the change in temperature (ΔT) can be measured in either kelvin _____ degrees Celsius and is defined as the _____ between the final temperature T_f and the initial temperature T_i .

Equation:

The specific heat capacity can then be in (J/kg·K) or in (J/kg·°C). This is a specific property unique to every material. Here is a list of common specific heat capacities:

Substance	$c/\text{J kg}^{-1} \text{K}^{-1}$	Substance	$c/\text{J kg}^{-1} \text{K}^{-1}$
Aluminium	900	Ice	2100
Iron/steel	450	Wood	1700
Copper	390	Nylon	1700
Brass	380	Rubber	1700
Zinc	380	Marble	880
Silver	230	Concrete	850
Mercury	140	Granite	840
Tungsten	135	Sand	800
Platinum	130	Glass	670
Lead	130	Carbon	500
Hydrogen	14000	Ethanol	2400
Air	718	Paraffin	2100
Nitrogen	1040	Water	4186
Steam	2000	Sea water	3900

Note: To earn full marks when solving science word problems, you must Show your work. Don't forget to convert units into the proper base units before calculating.

Example Problem:

1. How much energy would be required to raise the temperature of a gold ring from 31.0°C to $1\,064^{\circ}\text{C}$ (the melting point of gold)? Let's assume the ring has a mass of 5.00 g and the specific heat capacity of gold is $129\text{ J/kg}^{\circ}\text{C}$.

Solution:

For all these problems we will need the specific heat capacity of each substance. Sometimes it will be given to you, but if not, look it up.

Practice Questions: (Your solutions should be organized similar to the example problem. Show all your steps please)

An online specific heat capacity table is available here: goo.gl/65gAMu

1. How much heat energy is required to warm 3.5 kg of water from 16°C to 96°C?
2. What is the mass of a lead block if it takes 67 kJ to raise the temperature by 100.0°C?
3. If a pile of snow ($c=2090\text{J/kg/k}$) with a mass of 525 kg loses 7.40 MJ of thermal energy during the night, how much will the temperature of the snow drop?
4. What is the final temperature of 0.63 kg of water that releases 2290 joules of thermal energy? The water had an initial temperature of 48.2°C.

5. What is the **total** thermal energy in a human body? Let's assume some things: The average specific heat capacity of a human body is approximately $3500 \text{ J/(kg}\cdot\text{K)}$ at normal conditions. The average human has a mass of 72.0 kg . Body temperature is normally $37.0 \text{ }^{\circ}\text{C}$.

6. In his part time job as a blacksmith, Nathan was quenching (cooling) a 350 g iron horseshoe from $470.0 \text{ }^{\circ}\text{C}$ to $30.0 \text{ }^{\circ}\text{C}$ by plunging the horseshoe into a bucket of cold water. How much thermal energy was lost by the horseshoe?

7. If the bucket of water that Nathan (from the last question) contained 14.0 kg of water that had an initial temperature of $25.0 \text{ }^{\circ}\text{C}$, how much would the water temperature increase when cooling the horseshoe? The energy lost by horseshoe is the energy gained by the water...

8. A standard gold bar ($c=129 \text{ J/kg}^\circ\text{C}$), also referred to as gold ingot or gold bullion has a mass of 12.4 kg (what is known as 400 troy ounces). If the melting point of gold is 1063°C , how much energy would be needed to bring one standard gold bar from room temperature of 20.0°C to its melting point?
9. If two bars of copper and gold have equal masses of 250 g, and have equal starting temperatures, how much will their final temperatures differ by if 6.5 kJ of thermal energy is added to each of the bars?
10. Milan started a fire in her fireplace which has a granite surround with a mass of 240 kg. If the granite started at 18.0°C , how much energy was needed to raise its temperature to 32.0°C ?