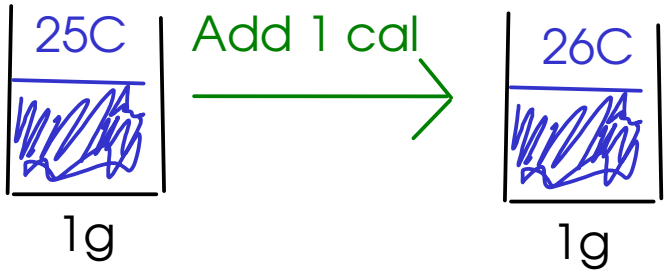
Energy units

- two common units. Both are based on the metric system

1 CALORIE

- the amount of energy required to change the temperature of one gram of water by 1 degree Celsius.

- abbreviation: cal



(One gram of water has a volume of approximately one milliliter)

- the Calorie reported on the side of most food labels is actually a KILOCALORIE (kcal). 1 kcal = 1000 cal

2 JOULE

- the standard metric unit of energy is the JOULE.

- abbreviation: J

- the Joule is defined based on KINETIC ENERGY, but is smaller than the calorie.

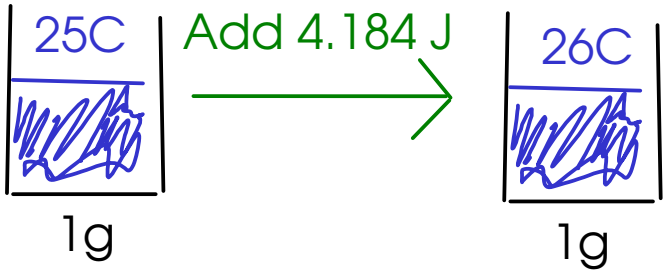
4.184 J = 1 cal

The joule is a DERIVED UNIT:

$1\ J = 1\ \frac{Kg\ m^2}{s^2}$, from

$E_K = \frac{1}{2} m v^2$

kinetic energy — mass — velocity



(One gram of water has a volume of approximately one milliliter)

Energy conversions

- It's simple to convert back and forth between calorie-based units and Joule-based units. Just use dimensional analysis! Remember that these energy units are both based on the metric system, and use the metric prefixes.

Example:

Convert 15.7 kJ to cal

$1\text{ kJ} = 10^3\text{ J}$

$4.184\text{ J} = 1\text{ cal}$

$$15.7\text{ kJ} \times \frac{10^3\text{ J}}{1\text{ kJ}} \times \frac{1\text{ cal}}{4.184\text{ J}} = 3752.390057\text{ cal}$$

Round this answer to THREE significant figures, since the original measurement (the 15.7 kJ) has three significant figures.

3750 cal

(3.75×10^3 cal)

HEAT

- is the flow of energy from a region of high temperature to a region of low temperature

- can be measured by monitoring temperature changes

Since heat is a FLOW of energy, it has a direction. The direction is indicated by a SIGN ... positive for energy flowing in, and negative for energy flowing out..

When we talk about heat, we need to be specific ... from where does energy flow, and where does it go?

SYSTEM: the object or material under study

SURROUNDINGS: everything else

And when we talk about processes involving heat, we need an easy way to describe them...

Type of process	Energy is ...	Sign of Q	Temp of SURROUNDINGS ...
ENDOTHERMIC	transferred from SURROUNDINGS to SYSTEM	+	decreases
EXOTHERMIC	transferred from SYSTEM to SURROUNDINGS	−	increases

(Why is the temperature of the surroundings important? Because the thermometer is usually part of the surroundings!)

SPECIFIC HEAT

- the same amount of energy will change the temperature of different substances by different amounts.

- the SPECIFIC HEAT is the amount of energy required to change the temperature of one gram of a substance by 1 degree Celsius

Units: $\frac{J}{g\,^{o}C}$ OR $\frac{cal}{g\,^{o}C}$

See the table of specific heats on page 297 of your textbook for values!

Water's specific heat is: $4.184\ \frac{J}{g\,^{o}C}$ OR $1\ \frac{cal}{g\,^{o}C}$

The higher the specific heat, the more energy is required to change the temperature!

Using specific heat

- specific heat is used to relate energy to temperature changes.

ENERGY = MASS × SPECIFIC HEAT × TEMPERATURE CHANGE

Example:

How much energy does it take to raise the temperature of a 15.4 gram piece of copper from 25.2 C to 100.0 C?

Specific heat of copper (Google search): $0.385\ J/g^{\circ}C$

$$\text{Energy} = (15.4\,g)\times(0.385\ J/g^{\circ}C)(100.0^{\circ}C - 25.2^{\circ}C)$$

$$(100.0^{\circ}C - 25.2^{\circ}C) = 74.8^{\circ}C$$

$$= 443.4892\ J$$

$$= \boxed{443\ J}$$

← Notice the sign of this number. Positive ... because the copper must take in energy to warm up to 100 C!

3 significant figures!

Note: In energy calculations, TEMPERATURE CHANGE is always FINAL TEMP - INITIAL TEMP!

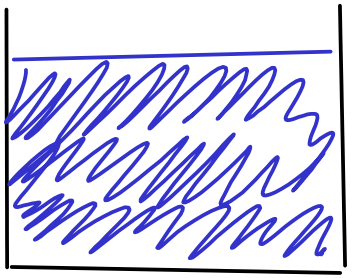
Measuring specific heat

- We can measure the specific heat of a solid sample by taking advantage of conservation of energy

Zinc metal sample

MASS: 50.2871 g

INITIAL TEMP 99.7 C

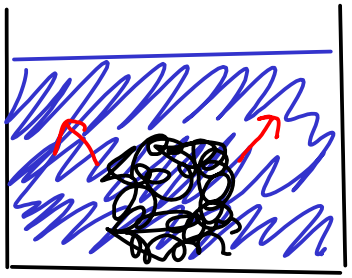


Room-temp water sample

MASS: 50.0 g

INITIAL TEMP 22.2 C

We'll heat the zinc sample up to a constant temperature using a boiling water bath (because it's easy to get a constant temperature this way)!



FINAL TEMP OF ZINC AND WATER MIXED: 28.9 C