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

$$4.184\ J = 1\ cal$$

$$10^3\ J = kJ$$

Conversion factors

$$15.7\ kJ \times \frac{10^3\ J}{kJ} \times \frac{1\ cal}{4.184\ J} = 3752.39\ cal$$

Round this answer to three significant figures, since the original measured number (15.7 kJ) has three significant figures!

$$3750\ cal$$

$$3.75 \times 10^3\ cal$$

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

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

See the table of specific heats on page 73 of your textbook for values!

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

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

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?

The specific heat of copper is 0.384 J / g °C

$$\text{Energy} = (15.4\ g) \times \left(0.384\ \frac{J}{g\,^{\circ}C}\right) \times (100.0^{\circ}C - 25.2^{\circ}C)$$

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

$$= 442.33728\ J$$

$$= 442\ J$$

See p 74-76 for more examples!

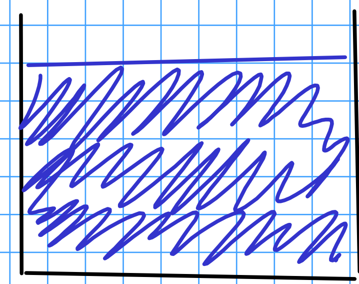
Measuring specific heat

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

Zinc metal sample

MASS: 50,3680 g

INITIAL TEMP 99.3 C

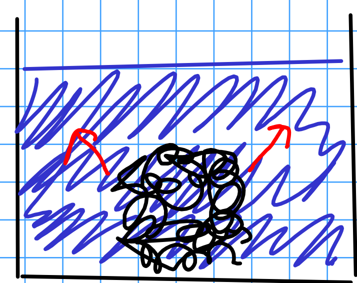


Room-temp water sample

MASS: 50.0 g

INITIAL TEMP 21,9 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: 29,2 C

Water:

ENERGY = MASS × SPECIFIC HEAT × TEMPERATURE CHANGE

$$29.2\,^\circ C - 21.9\,^\circ C = 7.3\,^\circ C$$

$$\text{ENERGY} = 50.0\ g \times 4.184\ \frac{J}{g\,^\circ C} \times 7.3\ ^\circ C$$

$$= 1527.16\ J$$

This number has two significant figures, but we'll wait until the final answer to round!

By conservation of energy, this energy gained by the water is also equal to the energy LOST be the zinc!

Zinc:

$$\text{SPECIFIC HEAT} = \frac{\text{ENERGY}}{\text{MASS} \times \text{TEMPERATURE CHANGE}}$$

The temp change of the metal is different from the temp change of the water!

$$99.3\,^\circ C - 21.9\,^\circ C = 77.4\,^\circ C$$

$$\text{SPECIFIC HEAT} = \frac{1527.16\ J}{50.3680\ g \times 77.4\ ^\circ C}$$

$$= 0.39\ J/g\,^\circ C$$

$$0.391731840 7\ J/g\,^\circ C$$