Energy

- can be defined as the ability to do work.

Work?

- the ability to move matter

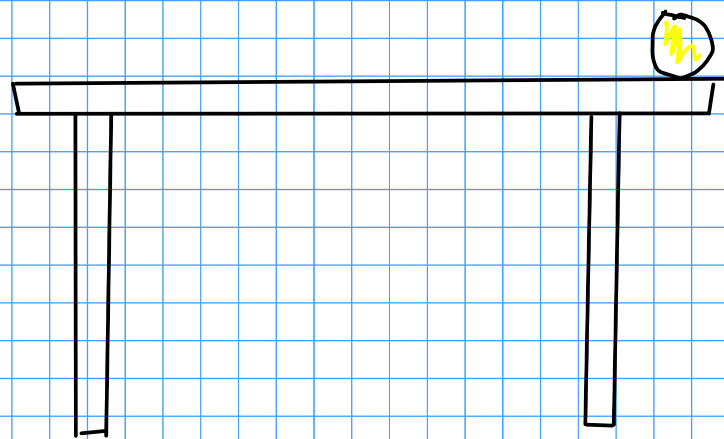
Kinds of energy

KINETIC ENERGY is the energy of matter in motion

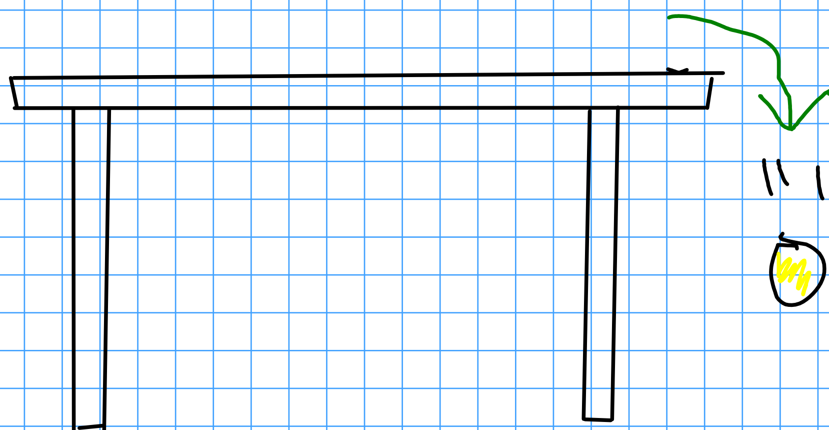
Throwing a ball gives it kinetic energy!

POTENTIAL ENERGY is energy of matter that is being acted on by a FIELD OF FORCE

- Fields of force may be things like gravity, magnetism, electricity, etc.



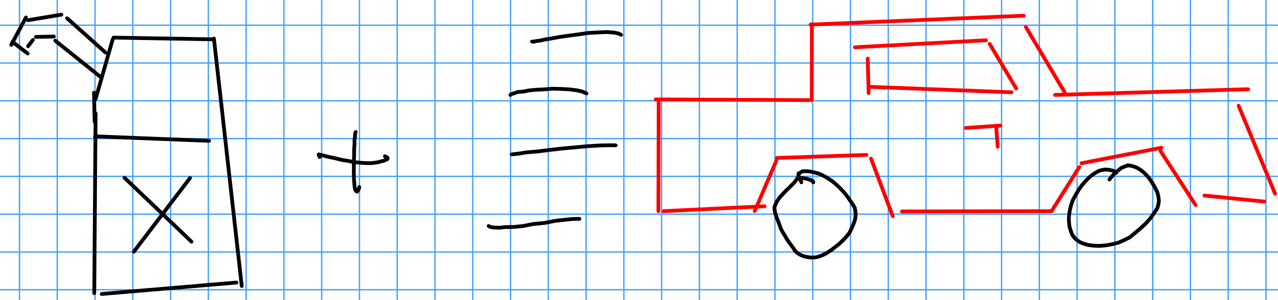
A ball on a table has POTENTIAL ENERGY because it is being acted on by GRAVITY



When the ball falls, the POTENTIAL ENERGY is converted to KINETIC ENERGY

CHEMICAL ENERGY is energy stored in matter. Think of chemical energy as the sum of the kinetic and potential energy of the atoms in a chemical

CHEMICAL ENERGY may be converted to other forms of energy during chemical reactions



Gasoline   Car's internal combustion engine

The chemical energy of the gasoline is CONVERTED to thermal and kinetic energy when the gas is burned in the engine of the car.

Conservation of energy

- Like mass, energy is conserved in physical and chemical changes.

- During a chemcal or physical process, the overall amount of energy remains constant, even if there is a change in the type of energy.

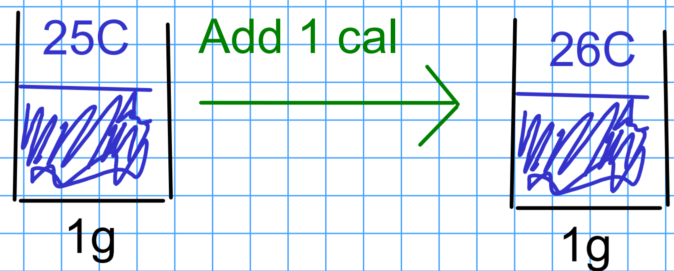
Energy units

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

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

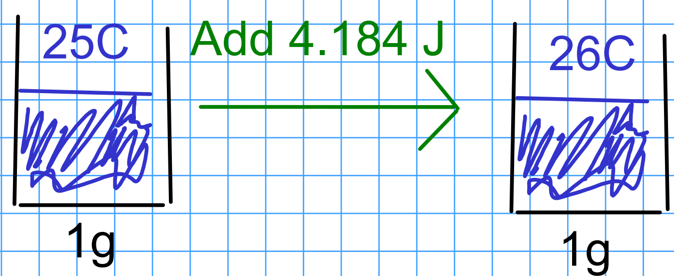
JOULE

- 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



(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

$$4.184\ J = 1\ cal$$
$$kJ = 10^3\ J$$

Conversion factors

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

$$= \boxed{3750\ \text{cal}}$$

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

p73 table of sp ht

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

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?

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

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

74.8 °C

$$= 442.33728\ J$$

$$= 442\ J$$

See p 74-76 for more examples!

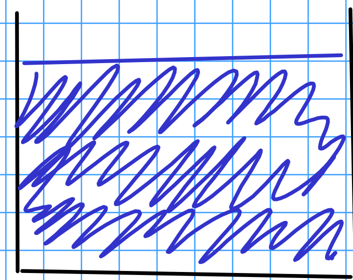
Measuring specific heat

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

Zinc metal sample

MASS: 50.6826 g

INITIAL TEMP 99.7 C

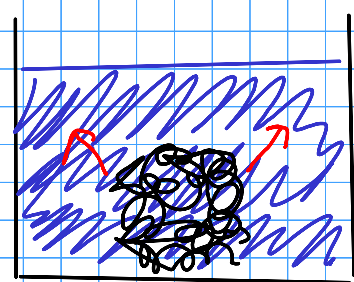


Room-temp water sample

MASS: 50.0 g

INITIAL TEMP 21.7 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: 28.5 C

Water:

ENERGY = MASS × SPECIFIC HEAT × TEMPERATURE CHANGE

$$\begin{array}{r} 28.5 \\ -\ 21.7 \\ \hline 6.8 \end{array}$$

ENERGY = 50.0 g × 4,184 $\frac{J}{g\,°C}$ × 6.8 °C

= 1400 J   1422,56 J

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!

$$\begin{array}{r} 99.7 \\ -\ 21.7 \\ \hline 78.0 \end{array}$$

1422,56 / 3953

$$\text{SPECIFIC HEAT} = \frac{1422.56\ \text{J}}{50.6826\ \text{g} \times 78.0\ °\text{C}}$$

= 0,36 J/g°C   0.359846352