Workshop 5E
Teaching Entropy with Fun

Regina Rüffler, Georg Job

c/o. Institute of Physical Chemistry,
University of Hamburg

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Bimetallic Jumping Disc

Procedure:
The disc consisting of two layers of different metals is warmed and then “clicked” into the “inverted” shape. Subsequently, the disc is placed on the table.

Observation:
After a short while, the disc suddenly snaps back into its original shape with a loud click and jumps into the air.

Explanation:
When the entropy of the bimetallic disc is increased, the two metals expand differently and above a temperature of approx. 310 K the disc stays in the “inverted” position. When the disc cools down, the metals shrink again and the disc returns spontaneously to its original shape.
Thermostat

Bimetallic strips are used as switches in thermostats.
Fire Piston

Procedure:
A small piece of tinder is poked into the hole in the lower piston. Then, the upper piston is forced vigorously down.

Observation:
The tinder ignites with a bright flash.

Explanation:
When a fixed mass of gas such as air is compressed rapidly it becomes glowingly hot (adiabatic compression). (If this compression is not done quickly enough the entropy has time to flow from the hot gas into the cold cylinder walls and the gas cools down.) This effect can be used to ignite a piece of tinder. Thereby, the air in the cylinder acts simultaneously as an oxidizer.
Diesel Engine

This effect can also be utilized in diesel engines to ignite the fuel-air mixture.

from: Oldtimer TV
Temperature Change in Expanding Rubber

Procedure:
A rubber band is touched with the upper lip, stretched quickly and pressed again against the upper lip. Then, the stretched band is allowed to contract and pressed against the upper lip.

Observation:
When the rubber band is stretched it feels noticeably warm. However, when the stretched band is allowed to contract there is a noticeable cooling.
Rubber and Entropy

Rubber consists of very long chains of polymerized molecules. The chains are held together by weak intermolecular forces but also by covalent disulfide bonds (crosslinks). The crosslinks prevent the polymer chains from moving independently. In the unstressed state, the chains are wildly tangled up.

If one stretches the rubber, the messy tangles line up to a certain degree; the disorder and therefore the entropy decreases. The excess entropy is transferred to the environment what causes the observed increase in temperature.

When the rubber band relaxes, the polymer chains curl up again; the required entropy is “soaked up” from the environment what is the cause for the decrease in temperature.
**Pop-Pop Steam Boat**

**Procedure:**
The boiler of the boat is filled with water. Subsequently, the candle is lighted and the holder placed underneath the boiler.

**Observation:**
After a short while, the boat begins to move with the typical “popping” noise.

**Explanation:**
The pop-pop boat is powered by a very simple heat engine (“thermal motor”) without moving parts. The released energy is used to operate the boat.
Pop-Pop Steam Boat

In the beginning of the cycle the water in the boiler is heated by the candle.

When the water boils it creates a brief burst of wet steam, which is expelled through the pipes in the rear of the boat and the boat moves forward.

Upon leaving the boiler, some of the steam condenses in the cooler part of the pipes thereby creating a partial vacuum.

This results in a refilling of the pipes and the boiler with water. The cycle can begin again.
Ponyo’s Boat

But there is also a surprising sighting of the boat in the world of cinema. The Japanese animator Hiyao Miyazaki has used it in his film “Ponyo.” Sōsuke, a little boy, owns a pop-pop boat that he’s fond of, and during a crisis, it grows by the power of magic large enough for two children to ride in.
Low Temperature Stirling Engine

Procedure:
The Stirling engine is placed on top of a cup with hot water. After waiting for a short while, the flywheel is gently pushed.

Observation:
The Stirling engine runs as long as the water in the cup is warm enough.

Explanation:
Stirling engines operate with a temperature difference between the plates. The displacement of the air from the hot to the cold region of the engine and vice versa by means of the displacer disk causes a periodic compression and expansion of the gas, which in turn results in a periodic movement of the power piston.
Low Temperature Stirling Engine

Principle of the engine (3D animation)

from: German Infotainment Show “Galileo”
Procedure:
Both blocks have room temperature. Nonetheless, one of the block feels cool whereas the other feels warm. Subsequently, an ice cube is placed in the middle of each block.

Observation:
The ice on block A (which feels cool) melts much faster.

Explanation:
Block A is made of aluminum, block B, however, of high density foam. Aluminum is a very good entropy conductor, high density foam a very bad one. The entropy flow by conduction always takes place in the direction of a temperature drop. Therefore, the (warmer) metal transfers entropy to the (colder) ice, which begins to melt as a result. The metal block feels cool at the beginning for the same reason.
Rapid Defrosting Trays

The same principle is used by the so-called “rapid defrosting trays” for frozen food such as meat.
Entropy Conduction in Metals

Procedure:
Each piece of chocolate is skewered with one of the three thin rods made of different metals. The rods are taped to the inside edge of a cup. Then, the cup is filled with hot water.

Observation:
After a while, two of the pieces of chocolate slide down in the direction of the water one after another.

Explanation:
First, the piece of chocolate in contact with metal B (copper) slides down, then follows the one in contact with metal C (brass). The piece in contact with metal A (steel), however, does not slide down. This sequence reflects the different entropy conductivities of the metals with the highest value for copper.
Thank you very much for your friendly attention.

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