

Rubber band

Topic

Polymers, exothermic reactions, endothermic reactions, thermodynamics, energy.

Timing

30 min.

Description

Students stretch a rubber band and test the effect of heat on a stretched band.

Apparatus and equipment (per group)

- Rubber band (at least 0.5 cm wide)
- Hair dryer
- Weight (>1kg)
- Ruler.

Teaching tips

The depth of treatment depends on the ability of the students. Students should recognise the difference between exothermic and endothermic reactions. A rubber band width of 1–1.5 cm and a 2 kg mass works well. A ruler standing beside the apparatus is effective as students can see the contraction as it occurs.

Another alternative is to use a clampstand and adjust the height of the weight until it just touches the bench. It is then easy to observe contraction of the rubber band.

Background theory

By placing the rubber band against their lips, students may detect the slight warming that occurs when the rubber band is stretched (exothermic process) and the slight cooling effect that occurs when the rubber band contracts (endothermic process).

The equation $\Delta G = \Delta H - T\Delta S$ (where ΔG means change in Gibb's free energy, ΔH is enthalpy change, ΔS is entropy change and T is the absolute temperature) can be rearranged to give

$$T\Delta S = \Delta H - \Delta G.$$

The stretching process (exothermic) means that ΔH is negative, and since stretching is non-spontaneous (that is, ΔG is positive and $-\Delta G$ is negative), $T\Delta S$ must be negative. Since T , the absolute temperature, is always positive, we conclude that ΔS due to stretching must be negative. This tells us that rubber under its natural state is more disordered than when it is under tension. When the tension is removed the stretched rubber band spontaneously snaps back to its original shape; that is, ΔG is negative and $-\Delta G$ is positive. The cooling effect means that it is an endothermic process ($\Delta H > 0$), so that $T\Delta S$ is positive. Thus, the entropy of the rubber band increases when it goes from the stretched state to the natural state.



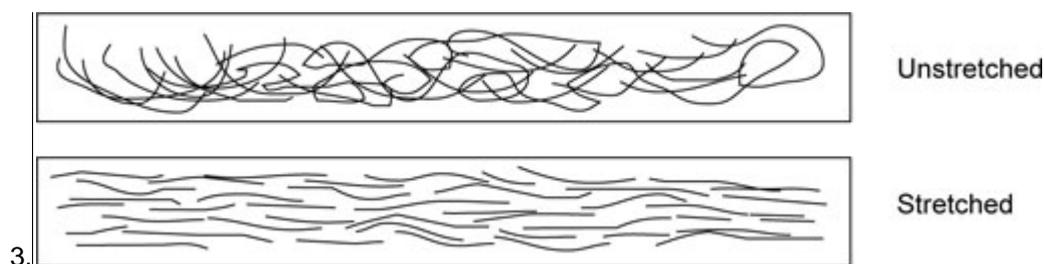
Safety

Ensure rubber bands are sterile and clean. Everyone should have his or her own band.

Ensure that if rubber bands break, weights do not drop on toes! Hairdryers should not be brought from home.

Answers

1. Contraction.
2. They should observe that the rubber band contracts when heated, which may well be the opposite of what they have predicted. The most simplistic answer may be that since the endothermic process is favoured when heating occurs, this is a contraction in the case of the rubber polymer since this is the endothermic process.



Credits

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