Rubber band experiment – teacher notes

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

Equipment
Apparatus
- Eye protection
- Rubber band, 0.5 cm wide (one for each participant)
- Hair dryer
- Weight >1 kg
- Ruler

Health, safety and technical notes
- Read our standard health and safety guidance here https://rsc.li/3ELKqRS
- Always wear eye protection.
- Ensure rubber bands are sterile and clean.
- Ask participant to stand back so that broken rubber bands do not drop weights onto feet.
- Hairdryers should not be brought from home, ensure all electricals used have an up-to-date pat test.

Notes
- 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.

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 nonspontaneous (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.

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.
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