

Rubber Band Equilibria

A rubber band is composed of numerous polymer chains. In the relaxed state the atoms have significant freedom of movement or vibration. (See Figure 1a.) When the polymer is stretched its atoms have less freedom of movement and therefore less vibrational energy. (See Figure 1b.) Is there a change in energy when a rubber band stretches or contracts? Try the following activity and find out.

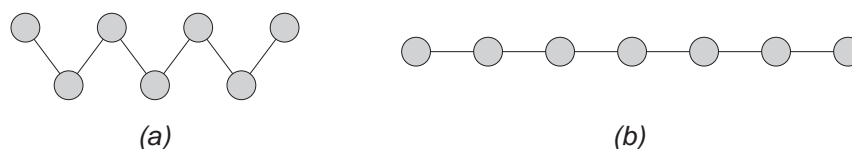


Figure 1: Polymer unit when (a) relaxed and (b) stretched.

Materials

- wide rubber band
- six-pack plastic ring

Exploration

- Step 1 Examine the rubber band. When you pull on opposite sides it stretches; when you release one end it contracts. Is the stretching and relaxing of the rubber band a reversible process?
- Step 2 Hold the rubber band against your upper lip or forehead for several seconds and notice how it feels. Move it away from your lip, then quickly stretch it and touch it to your lip again. What change, if any, do you feel? Hold the stretched rubber band against your upper lip. Move it away, allow it to contract, and touch it to your upper lip or forehead again. What change, if any, do you feel?
- Step 3 From your observations in Step 2, what can you conclude about what is happening to the rubber band? Can you explain your observations in terms of the polymer strands? Do these conclusions change your answer from Step 1 about the reversible process? Explain. Write a reversible equation which relates the rubber band in stretched form to the rubber band in relaxed form.
- Step 4 State LeChatelier's principle. Use your equation from Step 3 to predict what would happen to a partially-stretched rubber band that was heated by a hair dryer. Would you expect a copper wire to expand or contract when heated? What is the general behavior of most substances when heated?
- Step 5 Hold one of the six-pack rings against your upper lip or forehead. Move it away, then quickly stretch it and touch it to your lip again. Do you notice a temperature change?

Challenge

How can the stretching and relaxing of a rubber band be related to equilibrium concepts?

Rubber Band Equilibria

Concepts

reversible processes, polymers, LeChatelier's principle, equilibrium

Expected Student Responses to Exploration

Step 1 Yes, it is a reversible process.

Step 2 (a) The rubber band feels warmer after it is stretched.

(b) The rubber band feels cooler after it contracts.

Step 3 (a) The rubber band loses heat when it stretches and gains heat when it contracts.

(b) Stretching the rubber band causes a decrease in vibrational energies; it converts that energy into heat as observed by a temperature increase. Conversely, relaxing the rubber band causes an increase in vibrational energies, which results from the conversion of heat, as observed by a temperature decrease.

(c) No, the observations are consistent. The heat released when the rubber band stretches is regained when it contracts.

(d) stretched rubber band + heat \leftrightarrow contracted rubber band

Step 4 (a) If a system at equilibrium is disturbed, the system will shift its equilibrium position so as to counteract the effect of the disturbance.

(b) The rubber band would contract when heated.

(c) A copper wire would expand when heated.

(d) The general behavior of substances is to expand when heated.

Step 5 Yes, the six-pack ring became warmer (even warmer than the rubber band in Step 2).

Expected Student Answer to Challenge

The stretching and relaxing of a rubber band is an example of a reversible process. LeChatelier's principle can be applied to predict how adding or removing heat will affect a rubber band.

Acknowledgment

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