

The scenario

Subject (field/title)	Thermal properties of matter / Balloons in liquid nitrogen.
Length of movie	2:51
Main Goals	Changes in state and volume due to changes in temperature
Detailed Goals	The change in the volume of gas due to a change in its temperature.
Structure and description of the experiments	
1. Introduction	Explanation: Substances change their volume as a result of temperature changes, and so do gases.
2. Main topic	Description: The film presents a change in the volume of air enclosed in a balloon due to a change in its temperature.
Part 1	<p>Tools: Two large beakers, placed one inside the other and thermally insulated from each other, liquid nitrogen, inflated balloons (so that their diameter is slightly smaller than the beaker used), wooden pliers.</p> <p>Description: Pour liquid nitrogen into the beaker. Use pliers for dipping the balloons into liquid nitrogen. It can be seen that the volume of air in the balloons decreases rapidly, and the rubber from which the balloon is made stiffens. Then, one by one, we pull the balloons out of the liquid nitrogen and observe the air volume in the balloons increasing again. Using transparent balloons, it is possible to observe the liquefied air inside the balloon (the boiling point of the air is about -191°C, which is slightly more than 4°C higher than the boiling point of liquid nitrogen, therefore observation of the liquefied air is only possible for a very short time after the balloon is pulled out of the liquid nitrogen).</p> <p>Questions: Does the air in such a cooled balloon have no volume? Why does the volume of a gas decrease as the temperature decreases and increase as the temperature increases?</p> <p>Conclusions: As a result of lowering the temperature, the gas volume decreases due to the decrease in the average kinetic energy of the gas particles and, thus, the decrease in the distance between the particles. When the gas temperature is reduced below the boiling point (i.e. below the liquefaction temperature), the gas molecules will be so close together that it will become a liquid. As the temperature of the gas starts to rise again, the molecules will start to increase their average kinetic energy and start to move apart, increasing the volume of the gas.</p>
3. Summary and notes	<p>Students should be reminded that cooling a substance means lowering the average kinetic energy of the molecules that make up the substance. Similarly, with heating - it is an increase in the average kinetic energy of substance molecules.</p> <p>Level: primary school and high school</p>

