Student experiment (5th - 10th grade)	**The fireproof balloon**	**Time:** max. 10 min.

Instruments:

- 2 balloons
- 2 candles

Experiment:

- Fill one of the balloons with a small quantity of water.
- Blow up the second balloon with the same volume of air. Hang both balloons at the same height above two candles.
- Light the candles and let them burn at a distance of approximately 3 cm under the balloons.

Observations:

One balloon pops, the other does not.

Results:

The skin of the balloons is heated from underneath. However, the heat transfer properties of air and water are very different. Air is a gas mixture and has very few particles in contact with the balloon's skin at any given moment due to the relatively large distances between the gas molecules. The air can therefore not transfer the incoming energy into inner energy fast enough to dissipate it. The skin temperature of the balloon rises rapidly, until the balloon explodes. The water-filled balloon, however, has many molecules of water in contact with the balloon skin, which speeds up the heat exchange and pulls warmth away from the balloon and into the water mass. The heat energy must warm the total volume of water, which happens only slowly in comparison to air due to the large number of water molecules involved. Additionally, the water molecules constantly churn, thus pulling the added heat away from the heated spot, cooling the skin. The temperature of the balloon skin is regulated by an equilibrium between the energy added by the candle flame per second and the energy absorbed by the water mass per second, so that the energy level needed to destroy the skin is never reached. Water's high specific heat means that the entire mass of water must be raised to the critical temperature necessary to destroy the balloon before it will pop. This entails a gigantic amount of energy in comparison to the relatively small amount of warmth required under the same conditions with the air-filled balloon. A given volume of air consists of only about 1% particles per unit volume with the rest being empty space. On the other hand, most typical liquids are composed of roughly >95% of particles per unit volume with less than 5% empty space. This means that a vastly larger number of particles are available to absorb added warmth before a specific increase in temperature occurs.

Template can be found online (in German):
http://portal.tugraz.at/portal/page/portal/Files/i5110/files/Forschung/Thermophysik/DA-RobertSchantl.pdf

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