A4 Evaporation heat – How to cool with heat

1 Why do you freeze in wet clothing?

1.6 Questions

a) Why do dogs pant when it is hot?

Answer: Unlike humans, dogs do not have sweat glands in their skin. Therefore, dogs cannot sweat and take advantage of the cooling effect of water evaporating from the skin's surface. But they have an alternative cooling system: panting, which is breathing in and out quickly and shallowly, passing a lot of air across a moist tongue. The water on the tongue's surface evaporates, cooling the tongue ("evaporative cooling"). Because the blood flow through tongue is very good, the blood is cooled by the evaporation before it flows back into the dog's body.

b) What other examples from everyday life can you think of in which cooling by evaporation also plays a role?

Answer: The phenomenon of "evaporative cooling" shows up in many everyday applications.
Clay jugs used for cooling work according to the same principle. Before it is used, the jug is moistened with water. In African countries, people use clay jugs soaked in water to cool food in order to store it longer.
Damp towels hung up in a room can provide cooling at the height of summer.
Clay houses in desert regions are natural air conditioners without the need for electricity: At night, the moisture in the air condenses on the walls and heats the house. During the day, the moisture evaporates again and heat is drawn from the walls.

2 How does a wet cotton pad cool you?

2.6 Questions

a) In the experiment, did you expect a greater cooling effect with a soaking-wet cotton pad or a dampened cotton pad? Explain your reasons.

Answer: If the cotton is moistened very slightly, very little water is available. This means only a little water can evaporate, and the cooling effect is small. If the cotton pad is soaking wet, at first there is a very strong cooling effect, because all of the water must first be heated to body temperature. This effect prevails over evaporation. When the water has reached body temperature, students may notice that the surface area of a closed water surface is relatively small. Due to this small surface area, the "evaporative cooling" effect is also not ideal when the cotton pad is soaking wet. In contrast, when a cotton pad is well moistened, every fiber is covered with water and air circulates between the fibers. For this reason, the rate of evaporation is high and resulting cooling effect is also the best of the three possibilities.

b) Imagine that you are in a very warm room that you would like to cool by evaporation. How would you do it?

Answer: Damp towels hung up in a room can provide cooling at the height of summer. As the water transitions from the liquid state to the gaseous state, the evaporating water extracts energy from the air, thus cooling the air. But a word of caution: If this process results in a "laundry room climate," meaning that the humidity in the room is extremely high, sweat on people's skin will no longer evaporate. This is also why people tolerate a dry heat at 32°C better than, for example, a moist heat at only 27°C.

c) How do you explain the cooling effects, or "evaporative cooling," with the particle model?

Answer: The drop in temperature during evaporation can be explained at the level of the smallest particles of the material. This is because a drop in temperature means a drop in the average velocity of the particles. The following table compares macroscopic observations with understanding at the particle level.

Macroscopic	In the particle model
A liquid has a specific tempera-ture.	The temperature is a measure of the average velocity of the particles. (More precisely: The temperature is proportional to the mean squared velocity.)
Some of the liquid evaporates.	Some particles may move at significantly higher velocities than others. The fastest particles have enough energy to escape the liquid's bonding force before the boiling point is reached. Evapo-ration is the vaporization of a liquid below the boiling temperature.
The liquid cools in the process.	Because the fastest particles are escaping the liquid's bonding force, the slower particles remain and thus lower the average velocity of the parti-cles. The cooled liquid now draws more heat from the warmer environment per unit of time (cooling effect).