Melting ice, boiling water

Aims of the experiment

- Understanding the various different states of matter (aggregate states)
- Transition of substances between different aggregate states
- Melting of ice (transition solid – liquid)
- Boiling of water (transition liquid – gaseous)

Principles

Substances may be present in different physical states (aggregate states). The classic aggregate states are solid, liquid and gaseous. Substances consist of particles that move continuously depending on their aggregate state.

Solids, that is, substances in a solid aggregate state, have a stable external form and a defined volume. In solids, the particles move very little. They are in a fixed grid in which they can only rotate and oscillate. The hotter it becomes, the faster the particles will rotate and the more strongly they will oscillate. As a result of the stronger oscillations, the particles need more room at higher temperatures, causing solid bodies to expand.

Liquids, that is, substances in a liquid aggregate state, also have a defined volume, but no longer any fixed form. In liquids, particles can move more freely. However, particles still interact with each other and are still in contact. As with solids, heating causes the movements of the particles to increase, causing liquids to expand when heated.

Water is an exception here: when it is heated, it contracts up to a temperature of 4 °C and only expands at higher temperatures. This is called the "density anomaly of water". The ice crystal does not break down completely during melting. The cavities of the ice fragments which form ("clusters") are occupied by free water molecules, so that water reaches its highest density at 4 °C. It is only above 4 °C that the clusters become smaller again, density reduces and water expands again.

Gases on the other hand, that is, substances in a gaseous aggregate state, have neither a form nor a volume and fill up any space available. In gases, particles are in fast motion. The particles only rarely come into contact and are evenly distributed across the entire available space.

At a constant pressure, substances pass at a characteristic temperature from one aggregate state to the next. These temperatures are known as melting points or boiling points and are listed in tables. Pressure influences these melting and boiling points. The boiling point decreases at lower pressure. This is

Fig. 1: Set-up of the experiment.

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why, for example, the temperature at which water boils is lower on high mountains than at sea level.

This experiment traces the behaviour of water at different temperatures. For this, ice - that is, water in a solid aggregate state, - is heated slowly until it melts and subsequently evaporates. At the melting or boiling point, the temperature only changes when the substance has fully passed into the state. In this way, it is easy for the melting point and boiling point to be determined.

Risk assessment

The test fundamentally does not pose any danger. However, care must be taken when handling hot objects and liquids.

Equipment and chemicals

1	Pocket-CASSY 2 Bluetooth	524 018
1	CASSY Lab 2	524 220
1	Rechargeable battery for Pocket-CASSY 2 BT	524 019
1	NiCr-Ni-Adapter S, Type K	524 0673
1	Temperature probe NiCr-Ni, Type K	529 676
1	Bluetooth-Dongle	524 0031
1	Beaker DURAN, 600 ml	664 105
1	Stirring magnet,15 mm x 5 mm Ø	666 850
1	Magnetic stirrer with hotplate	666 8471
1	Stand rod, 450 mm, 12 mm Ø	666 523
1	Universal clamp 0...80 mm	666 555
1	Bosshead S	301 09

Additionally required:
Ice
Computer with Windows XP/Vista/7/8

Set-up and preparation of the experiment

1. Screw the support rod into the magnetic stirrer with hotplate.
2. Attach the universal clamp to the stand rod using the bosshead S.
3. Connect the Pocket-CASSY 2 Bluetooth to the rechargeable battery for the Pocket-CASSY 2 Bluetooth. Insert the Bluetooth-Dongle into a USB port on the PC.

Note: Alternatively, connect the Pocket-CASSY 2 Bluetooth to the PC by means of a USB cable. In this case the battery for the Pocket-CASSY 2 is not required.

4. Connect the temperature probe NiCr-Ni via the NiCr-Ni-Adapter S to the Pocket-CASSY 2 Bluetooth.

Performing the experiment

1. Load settings CASSY Lab 2.
2. Crush the ice and add it to the beaker along with some water. Add the magnetic stirring rod and place the beaker on the magnetic stirrer with hot plate.
3. Attach the temperature probe NiCr-Ni to the universal clamp and insert it into the beaker.
4. Start the measurement in the CASSY Lab 2.
5. Set the stirrer to a low speed.
6. Switch on the heating plate and set to maximum heating.

Observation

The ice melts slowly. During melting, a temperature of approx. 0 °C is measured. After the ice has melted completely, the temperature of the water increases continuously. After being heated for some time, the water starts to boil. Bubbles rise. The temperature is now approx. 100 °C and does not continue to rise.

Evaluation

The evaluation takes place in CASSY Lab 2.

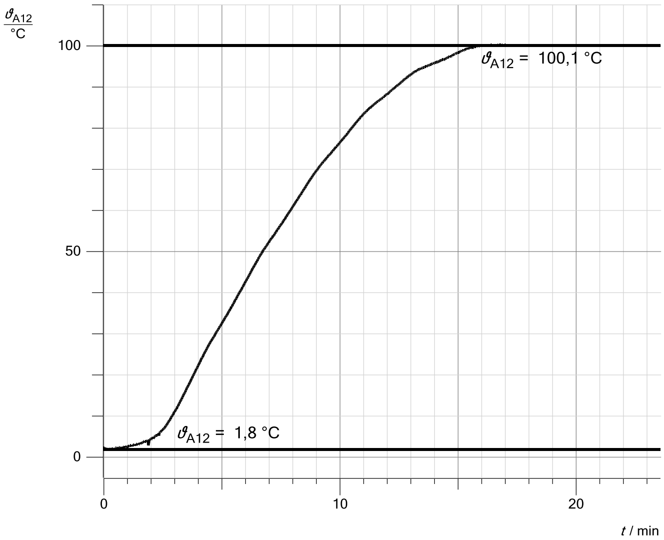

Fig. 2: Melting and boiling diagram for water.

As is clearly shown in Figure 2, the temperature initially remains approx. at a constant 0 °C, until all of the ice has melted. This is the melting point. Then there follows a continuous increase in temperature up to 100 °C. At 100 °C the boiling point of water has been reached, and the water is boiling.

Result

For the water in the aggregate state "solid" to pass into the liquid aggregate state, energy must be added to the ice. The temperature therefore remains approx. at a constant 0 °C during melting.

Something similar happens when the water starts boiling. When water reaches a temperature of 100 °C, a small portion of the water molecules passes from the liquid aggregate state to the gaseous aggregate state. It is only after all water has evaporated that the steam takes on a higher temperature. This observation only applies at normal air pressure at sea level (normal pressure). At lower pressures, e.g. on mountains, water boils at a significantly lower temperature.

Cleaning and disposal

After cooling, the remaining water is poured down the drain.