In this lab, we will be measuring how much energy it takes to melt ice and heat water. I have modified this lab to work with a microwave oven that you're likely to have at home.

Before the lab Before the day of the lab, you will need to collect your equipment. If you do not have a microwave oven, or do not have a liquid measuring cup, you will need to use the data from another student in your group. If you *do* have a microwave and a way to measure the volume or mass of water, please be ready to do this lab during class.

You will need the materials below. Ideally the day before the lab you will put about 500 mL (or even more) of water into a container (not a glass jar, which could break) and put it into the freezer so you will have a large chunk of ice. This will make it easier to separate the ice from the melt water when you melt it. If you do not do this you can still use ice from an ice cube tray, but then it will really help to also have a collander or seive to help separate ice from water.

Materials:

- Microwave-safe bowl or mug
- Microwave oven
- Kitchen scale or liquid measuring cup
- Ice and water
- Thermometer (if available)

Instructor's guide

This is the home version of Ice Calorimetry Lab for when there is a pandemic, or if you want students to do the activity at home. The accuracy students can get with a microwave oven is surprising, so I may adapt this to be a "home lab" even when we are teaching in person.

While the measurements are being taken, I asked the students a couple of small-whiteboard-questions, "What is heat?" and "What is entropy?". I then lecture on what the heat capacity C_p is, and how they could extract it from their data, and on how they can calculate entropy from their measurements: $\Delta S = \int \frac{dQ}{T}$.

We will be using a microwave oven to measure how much energy it takes to melt ice and how much energy it takes to boil water. If you have a thermometer, you can also measure how much energy it takes to raise its temperature. Our experimental unit of energy will be "seconds in the microwave." It's not a great unit of measure. A microwave may not always output equal power independent of what is in it, so we'll try not to change *too* much the amount of ice or water in the oven.

In the analysis, you can use the nominal power of the microwave (as written somewhere on the inside or outside of your oven) to approximately convert this to Joules, but keep in mind that this conversion is dubious on many fronts. There will be energy wasted in the electronics of the microwave, which is not transmitted to the ice. Also the documented power is probably rounded up, because it is used by electricians to determine whether the device is safe to put on a circuit, and for that purpose it is acceptable to use less than the documented power, but not more. We could do better by measuring the current drawn (and the line voltage), but I doubt you have that equipment in your kitchen.

Melting ice We will start by measuring how much energy it takes to melt a gram of ice. You will want maybe 500 mL of ice, or perhaps two ice cube trays. Prepare your ice for this experiment by putting it in a bowl of water for a bit. This will raise its temperature to zero Celsius. Put a bunch of ice (500 mL or two ice cube trays) into a microwave-safe bowl.

1. Microwave the ice for a minute.
2. Pour out the liquid water (possibly through a seive or a collander) into a liquid measuring cup to see how much of the ice was melted. Alternatively you could measure the mass of the melt water with a scale.
3. Repeat, but increase the time significantly if you didn't melt an eaasily measurable amount of water. Stop when you've melted at least half of your ice.

Boiling water We will now measure how much energy it takes to boil water. If you have a glass measuring cup, fill it to the highest mark with water. Add a pebble to the measuring cup (or bowl). Then microwave it until it reaches a full rolling boil. At this point the water should be 100° Celsius.

1. Put the water in the microwave, and heat it for three minutes.
2. Measure the amount of water remaining either by volume or mass.
3. Repeat, but increase the time significantly if you didn't boil an eaasily measurable amount of water. Stop when you've boiled away at least half of your water.

Heating water (optional) Now if you have a thermometer, you can find out how much energy it takes to raise the temperature of water. Start by filling a cup with water, making sure to measure its mass or volume.

1. Measure the temperature of the water and write it down.
2. Put the cup in the microwave for a little while (start with 30 seconds or a minute probably), and write down how long you heated it.
3. Repeat until it reaches boiling. Increase the time interval if your water does not change temperature by an easily measurable amount.