Laboratory 1B: Temperature Measurements

Purpose

Accurate measurements are essential to scientists’ ability to make observations and understand the world around them. The goal of this experiment is to understand the concept of error in measurements, and how to minimize them. We will be using temperature measurements and thermometers to demonstrate the general procedure and purpose for calibrating measuring instruments.

Discussion

Error’s in Measurements

In statistics error is the difference between the computed, estimated or measured value and the true, specified or theoretically correct value. Errors are not mistakes. All measurements however are subject to a variety of errors which can result in incorrect values. Several examples are human error (simply being human is enough to get some things wrong) are, incorrect procedures, broken measuring instruments, and poorly calibrated instruments. The goal of a scientist is to minimize the possible sources of error in any measurement. The list of ways to do this is large, but the most common ones used in class will be by following proper procedures, calibrating instruments, testing versus known quantities, and making multiple measurements.

Thermometer Basics

The simple act of measuring temperature with a thermometer can easily involve many errors. When measuring the temperature of a liquid one can minimize error by observing the following procedures:

1. Hold the thermometer away from the walls of the container.
2. The bulb of the thermometer should be fully immersed in the water.
3. Allow sufficient time for the thermometer to reach equilibrium with the liquid.
4. Be sure the liquid is adequately mixed.
5. Always make readings at eye-level.
6. Sometimes a note card placed behind the thermometer makes the mercury easier to see.

Some additional pointers for using a thermometer:

1. Thermometers are round. Round objects on flat surfaces (lab bench tops) tend to roll. Always place your thermometer such that it will not roll off the lab bench top.
2. Thermometers are fragile, do not use them as stirring rods. Stirring rods should be used to stir liquids.
3. Always secure your thermometer with a clamp.
4. Many thermometers contain mercury (a toxic heavy metal), if you break a thermometer immediately inform your instructor so the proper hazardous waste procedures can be followed.

Calibrating Your Thermometer

Calibration is the validation of specific measurement techniques and equipment. At the simplest level, calibration is a comparison between measurements of known quantities and the value obtained using the measuring instrument. Your first task will be to check the accuracy of your thermometer by calibrating it to two known values. The two temperatures you will use are transition between ice and water (melting point) which occurs at 0 °C and the transition from liquid to gas (boiling point) which occurs at 100 °C at sea level. The melting point is not affected to a noticeable degree by elevation, in contrast, the boiling point is affected by elevation. Those curious may read about this in Hein Ch. 13.5 (p. 305), Chang Ch. 11.8 (p. 466) or in McMurry Ch. 10.5 (p. 396). The boiling point is the temperature at which the vapor pressure of a liquid is equal to the external pressure (generally atmospheric pressure) above the liquid. In Rangely CO, we are at an elevation of approximately 1 mile, this will result in the lowering of the boiling point of water to approximately 96 °C .
Proper use of Bunsen Burners

We will be using Bunsen burners for the first time in this experiment. Bunsen burners can be found in the tall cabinets at the lab benches.

1. Check the rubber hose attached to the Bunsen burner for cracks or splits. Report any bad hoses to your instructor so they may be replaced.
2. Check the turn screw at the bottom of the Bunsen burner, and leave it partially open.
3. Clear the area of flammable substances.
4. Attach the hose to the stop-cock.
5. Turn the stop-cock perpendicular (90 degrees) to the pipe. Never adjust the amount of gas going to the Bunsen burner with the stop-cock, use the valve at the bottom of the burner. The stop-cock should always be either on or off, never between.
6. Adjust the flame using the screw at the bottom of the burner to adjust the gas flow, and the tube of the burner to adjust the oxygen flow. The goal is to form a small blue cone. The hottest part of the flame is the tip of the blue cone. It does not have to be large in order to provide the maximum amount of heat.
7. When done using a Bunsen burner turn it off at the stop-cock.
8. Replace the Bunsen burner in the cabinet.

Procedure

A. Experimental Setup

Set up the experiment as shown in Figure 1 and follow the directions given below.

B. Measure the melting point of ice

1. You will need a ring stand (in the cabinets under the lab benches), a ring clamp, wire pad, and a thermometer clamp.
2. Set up a ring stand as shown in Figure 1 and as can be seen at the instructor lab bench.
3. Have your instructor check your assembled apparatus before proceeding.
4. Fill a 500 mL beaker with approximately 75% ice and 25% distilled water.
5. Allow 3-5 minutes for the system to equilibrate.
6. Place the thermometer in the ice water solution and allow another 3-5 minutes for the system to equilibrate.
7. Record the temperature on the results page.
8. If your results are not within 2 °C of the expected temperature, consult your laboratory instructor.

C. Measure the boiling point of water

1. Place approximately 350 mL of distilled water in a 500 mL beaker. (75% full)
2. Place 1-2 *boiling chips in the beaker.
3. Place the beaker on the ring stand as shown in Figure 1. Be sure to cover the ring stand with a piece of wire screening to set the beaker on.
4. Light the Bunsen burner and adjust the flame such that the blue cone is just touching the beaker.
5. Allow the water to boil for 3-5 minutes to establish a consistent temperature.
6. Record the temperature of the water in the beaker.
7. If your results are not within 2 °C of the expected temperature of 96 °C consult your laboratory instructor.
8. Allow your water bath to cool before attempting to dispose of the water in the sink.
Laboratory 1B: Temperature Measurements

*Boiling results in the rapid formation of bubbles of air in a solution. In small containers (such as the beakers used in laboratory) or in pure liquids (such as the distilled water used in laboratory) the rapid formation of a large bubble can cause the beaker to "bump" or move abruptly causing it to be knocked off the ring stand. Boiling chips are used when boiling substances to prevent this from occurring by creating places for bubbles to form in a controlled manner.

D. Comparing Thermometers

1. Obtain a second thermometer from your instructor.
2. The thermometer you received is expensive, take extremely good care of it to avoid the wrath of your instructor.
3. Record your observations of the thermometer in the results section.
Results

1. Temperature can be read with what uncertainty (±) (cheap thermometer):

2. Temperature of ice-water bath:

3. Temperature of boiling water bath:

4. Temperature can be read with what uncertainty (±) (expensive thermometer)

Questions

1. Are we testing the accuracy or the precision of the thermometer in this experiment? Explain.

2. Why is the second thermometer much more expensive than the first thermometer (used to measure the freezing point and boiling point of water)? Explain.

3. Convert 225 °C to °F. Explain.

4. Convert 15.4 °C to °F. Explain.

5. Convert 400 °F to Kelvin. Explain.