Experiencing the World – Temperature and Graphing

Purpose

Temperature is an energy source that is experienced every day. Many industrial processes require the measurement, control and trending (graphing) of temperature values. This Experiencing the World exercise is meant to give students experience making process measurements and creating a graph of the data.

Prerequisite

Read the appropriate sections of the textbook relating to temperature, temperature sensors and temperature measurements.

Students performing and completing this exercise will

1. Experiment with measuring and graphing temperature readings.
2. Analyze several effects that the surrounding environment has on temperature.
3. Create a graph of temperature values (trends).

Equipment required

1. A vessel made of a material that can be heated and cooled and that can hold at least one quart (4-cups). Examples of vessels, but not limited to, could be:
   1. A stainless steel cooking pot.
   2. A Corningware® or Pyrex® pot.
   3. A tin or steel cooking pot.
2. One thermometer of any type provided the range is such that it can measure from 32°F (0°C) to 212°F (100 °C). If you do not have a thermometer one can be purchased at a store like Wal-Mart for under $5.00.
3. A source of tap water (city or well, not filtered).
4. Ice.
5. A source of heat (ex. kitchen range).
6. A stop watch or a clock or wrist watch with a second hand or seconds display.
7. Measuring cup.
8. A pad of paper and pencil or pen to record data.

Instructions

Read this entire exercise before starting. Then return to the beginning and perform each step.

What You Will Be Submitting

You will be submitting two files:

1. This completed lab document
2. Excel spreadsheet with the data collected and a graph

Name the files using the following file naming convention:

<Lastname>\_<Firstname>\_Trending\_Data

As an example, a student by the name of Data Collector would name their files:

Collector\_Data\_Trending\_Data

Procedure

* Make at least one tray of ice cubes or have some crushed ice ready.
* Using the measuring cup, measure the amount of water required to fill the vessel half full. Use at least 2-cups of a slush mixture. *(It should be apparent that the more water in the vessel, the longer it will take to reach boiling point).*
* Answer the following questions before proceeding:

1. What type and material is the vessel being used?

Random entry by student.

1. How much water is being used? Record your answer in ounces.

Random entry by student. Check that it is in ounces

1. What heating device is being used?

Random entry by student.

1. What is the range of temperature being measured? (Record the range in °F and °C).

Random entry by student. Check that it is a range.

1. What is the span of the temperature meter/thermometer being used? (Record the range in °F and °C).

Check that the span is correctly calculated.

1. What is the accuracy of the measuring instrument (if known)?

Random entry by student.

1. How many feet above or below sea level is your location? *(This information is available on the Internet).*

Random entry by studnet

1. Record the boiling point of water at sea level in: °F, °C, °R, °K

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| 212 | °F | 100 | °C | 671.67 | °R | 373.15 | °K |

1. Calculate or record the boiling point of water at the altitude in your location in: °F, °C, °R, °K

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| Student entered value | °F | Check for proper calculation | °C | Check for proper calculation | °R | Check for proper calculation | °K |

1. What temperature does water freeze? (Record the range in °F and °C).

32°F/0°C

1. Is the freezing point of water affected by altitude and why or why not?

There is little to no effect on the freezing point of water with altitude. Although water is one of the rare substances that expands when it is cooled, the expansion and molecular movement is so small that even a mountain climber would not notice the difference.

1. Is an ice cube 32°F (0°C)? Explain your answer.

It depends on the surrounding temperature. Water freezes at 32°F, however, if the surrounding air is colder, the ice will be colder.

1. What will happen to the temperature of ice when salt is added? Explain your answer.

Adding salt to ice will cause the temperature to drop. The drop in temperature slows the melting rate and increases the freezing rate. The net result is that the ice melts more and more slowly after the initial addition of salt.

When you add salt to an ice cube, you end up with an ice cube whose temperature is above its melting point. This ice cube will do what any ice cube above its melting point will do: it will melt. As it melts, it cools down, since energy is being used to break bonds in the solid state.

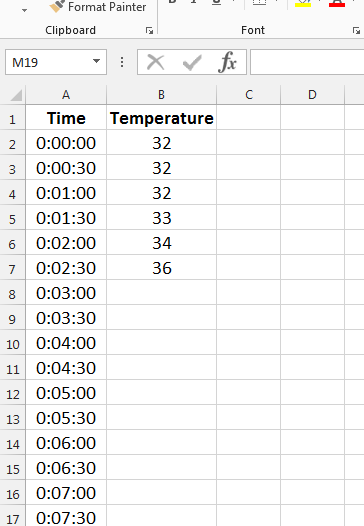
(Note that the above point can be confusing if you're new to thinking about phase transitions. An ice cube melting will take up energy, while an ice cube freezing will give off energy. I like to think of it in terms of Le Chatelier's principle: if you need to lower the temperature to freeze an ice cube, this means that the water gives off heat as it freezes.)

The cooling you get, therefore, comes from the fact that some of the bonds in the ice are broken to form water, taking energy with them. The loss of energy from the ice cube is what causes it to cool.

1. Can the temperature when water boils and when water freezes ever be equal? If so, when? If not, why not?

Yes… At the low pressure of 611 Pa (only 0.006 times atmospheric pressure), pure water boils at 0.01 °C, and it also freezes at 0.01 °C. The combination of conditions (P, T) = (611 Pa, 0.01 °C) is called the **triple point of water** because, at this pressure and temperature ice, liquid water and steam can coexist in equilibrium. This point is used to define our scale of temperature: by definition, the triple point of water occurs at 273.16 K, where K is the kelvin. 273.16 K = 0.01 °C

* Use and Excel spreadsheet to record the temperature data at 30 to 60-second intervals. A sample is shown in Figure 1. The spreadsheet shown is setup to take readings every 30-seconds.



Recorded temperature

Time in 30-second intervals

Figure

* Make a slush mixture by crushing enough ice to make approximately a 50% water, 50% ice mixture. Thoroughly mix this solution
* Place the temperature meter/thermometer; hence forth referred to as a T/C, into the solution so that it is not touching the vessel. Be sure to mount it in a way that the heat will not melt the T/C or damage the mounting.
* Record the temperature of the slush on the data sheet.
* Place the vessel on a heat source set to medium heat and record the temperature of the water in the vessel at 30 to 60-second intervals. (Thirty seconds was chose to give the final graph a smoother line.) Continue recording temperatures at 30 to 60-second intervals until the water in the vessel is boiling.
* When all of the data has been collected, graph the data using a line graph. Figure 1 shows an example of a graph created using a digital T/C and an electric range set to medium.

Figure 2

