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CTE Science Laboratory Investigation

THE COEFFICIENT OF EXPANSION OF POPCORN

**Introduction**

 All materials expand or contract depending on their temperature. If you’ve ever placed a glass bottle in the freezer to cool it off quickly, but then forgotten about it, you’re acutely aware that water expands considerably when it freezes. And perhaps your front door doesn’t close well in the summer (when it’s hot, and the door expands), but closes smoothly in the winter (when it’s cold, and the door contracts). The amount that a material expands or contracts for every degree of temperature change is called its coefficient of expansion. Depending on the application, the coefficient may be reported in millimeters per degree (when length is important), mL per degree (when volume is important), or even just in a ratio of the starting volume to the ending volume if a range of temperatures is important. It’s this last unit that we’ll use today.

In the case of train tracks, the coefficient of expansion of the steel used to construct the rails is of critical importance. If the steel heats up in the sun, the track can expand, warp and cause a derailment. See figure 1 for an example from a rail line in Iowa. For this reason, railway tracks are often heated before they are installed, or stretched and clipped down so that they won’t expand further.

Figure 1. A track in Iowa that has buckled because of the sun’s heat.

You might imagine that steel in a skyscraper, especially one in a city like New York, where it is very hot in the summer and very cold in the winter, must expand and contract as little as possible. Adding other elements to the steel can make it expand less. It’s similarly important that ALL The steel in the building be the same type; you wouldn’t want the north side of the building to expand more than the south side, and have the entire thing tilt.

Today, we’ll explore the coefficient of expansion of something a little less difficult to measure, and a little more tasty to eat: popcorn. Popcorn “pops” because the dried corn seeds have a very tough outer shell, and a starchy interior that has about 14% water in it. When heated, the water turns into steam and saturates the starch, forming a gel-like material. Eventually, when the pressure reaches about 930 kPa (about 135 psi), the shell ruptures, the starch flies out then cools into the fluffy snack we know and love. It will be your task to determine what the expansion coefficient of popcorn is, based on several experimental trials.

**Purpose**

The purpose of this investigation is to acquaint you with the idea of a coefficient of expansion, and to design, carry out and analyze an experiment. You’ll also reconnect with your graphing skilz and check your data against that of your classmates.

**Materials**

PENCIL Popcorn

Paper bag Calculator

Graduated cylinder Microwave oven

**Procedure**

Recall that a coefficient of expansion can be measured many ways, but for our application, we want to know what percentage of the starting volume the final volume is. We’ll use a ratio of two volumes, both measured in mL, so they will cancel out and the final coefficient will be dimensionless – it will have no unit!

1. Measure out a small amount of unpopped popcorn in a graduated cylinder. The exact amount you use isn’t critical, as long as you measure carefully. Make the amount somewhere between 10 and 20 mL. Record this exact amount in table 1.
2. Using a digital balance, find the mass of your popcorn. Record the mass in table 1.
3. Place your popcorn in a paper bag, fold the top over, and pop it on full power in the microwave. It should take about three minutes.
4. Find the final mass and volume of your popcorn, and record it in table 1.
5. Find a creative way to dispose of your popcorn. If you need salt or butter, you can find them on the front table.

|  |  |  |
| --- | --- | --- |
|  | **Initial** | **Final** |
| **Mass** |  |  |
| **Volume** |  |  |

Table 1. Data for popcorn coefficient of expansion calculations

**Analysis**

QUESTION 1: Determine your coefficient of expansion by dividing your final volume by your initial volume. You should get a number bigger than one.

QUESTION 2: Determine the change in mass in your popcorn by subtracting the initial mass from your final mass.

QUESTION 3: Was there a change in mass? Did some of your popcorn disappear? What could account for the change if there was one?

QUESITON 4: Enter your data on the class website and compare your results with those from other groups. Were the results similar or different?

QUESTION 5: Examine the graph that is generated from the class data. Make some observations about the shape of the line and explain what that might tell you.

QUESTION 6: Given your coefficient of expansion, how much unpopped popcorn would it take to fill our classroom if it was all popped?

QUESTION 7: What are two things that you would change about this lab if you could?