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Differentiation of Material Temperature through the Application of Increased Localized Dissolution via Heat Transfer

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Abstract

Increased temperature of a solution increases its solubility, allowing for a greater level of dissolution of the solute. A greater level of dissolution will result in a change in the density of the solution. When a localized area of the solution is of a different temperature, this will affect the localized density. Density is one of the factors affecting rate of sinking and the difference in temperature will lead to a change in the rate of sinking. Thus, when an object is at different temperatures, it will transfer heat to or from the solution in different manners and the rate of sinking will be different. This study tested whether sinking rate in a solution with excess solute could be used to judge the temperature of an object and the effect was confirmed with impure Graphite blocks in a Potassium Iodide solution.

Keywords

Calorimetry, Localized Heat Transfer, Density, Sinking

1. Introduction

In modern chemistry and engineering, calorimetry allows us to gauge the temperature of an object by utilizing the principle of specific heat capacities. However, common forms usually have several flaws as included below. 1) The most simple form of calorimetry regularly seen in laboratories with limited equipment is known as cup calorimetry. This requires the object and surrounding solution to achieve a state of thermal equilibrium which takes time, allowing heat to be lost to the surroundings and increasing the overall level of error involved. On the other hand, this has largely been corrected in more sophisticated processes. 2) The most common form of calo-

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rimetry is Differential Scanning Calorimetry (DSC) and it resolves the problem specified in 1). However, there are a few constraints to this method such as requiring prior knowledge of geometric parameters of the object such as surface area and volume [1].

As an alternative, localized heat transfer and its effect on the sinking of an object is a possible way to measure the temperature while avoiding 1) and 2). Thus this paper seeks to analyze the feasibility of using the relationship between localized heating on the density of a solution with excess solute to measure the temperature of objects regardless of geometric structure.

Problem 1) can be avoided due to the instantaneous nature of heat transfer and thus the very nature of the process allows us to know that this will be the case.

Problem 2) can be remedied by measuring the same object twice. First you can set a bar beforehand for the graphite, say X degrees. Then you measure its rate of sinking. Afterwards when you want to measure the temperature of the same object, all you have to do is to measure its rate of sinking as compared to the previous value with other variables kept constant; based on the difference between the values you can accurately gauge whether the temperature of the object is greater, less than, or equal to X.

2. Experimental Analysis

The test is to find if there was an actual correlation between the temperature of an object and its rate of sinking. It is not to create a basis to compare future experiments because all values are relative and based on the dimensions of the object which we choose to ignore. Thus all the experiment will involve in heating up an object to 2 different temperatures and measuring its rate of sinking in both cases.

2.1. Apertures

To begin with, the object chosen was a piece of graphite. This is because graphite is a very stable substance and very unlikely to react with a solution of choice and undergo deformation. Also graphite is low in density and will not sink too quickly, making measuring its rate of sinking easy.

For the solution, water is chosen as the solvent because it is a very common polar liquid. The solute chosen is Potassium Iodide (KI) because it has reasonable density and its solubility in water changes significantly with changes in temperature and in a rather linear fashion [2].

2.2. Method

I added excess KI into a beaker of water and heated it with a bunsen burner to the boiling point and let it boil until the water evaporated to a certain point. The solution was then allowed to cool to exactly 54˚C. A mechanical agitator was used to allow the salts to be partially suspended in the solution then stopped so as to prevent currents in the water interfering with the experiment.

After waiting approximately 3 seconds, a piece of impure graphite was placed into the solution. 2 markers were set on the side of the beaker to act as points of reference and a slow motion camera designed to slow the speed of the video by 4 times was set up 15 cm away from the beaker so as to prevent parallax error. The time taken for the graphite to pass between these 2 markers was then measured. This process was then repeated 3 times and the results were recorded.

This was then repeated with a piece of graphite heated over the Bunsen burner for 20 seconds.

3. Results

3.1. Data

Table 1 shows the Sinking Rates.

3.2. Analysis

The results showed that the piece of graphite in heated conditions took approximately 2.27 times as the amount of time to sink the same set distance. This shows a significant correlation between the temperature of the object and the rate of sinking.

Table 1. Table of sinking rates.

	Heated	Non-Heated
Trial 1 (s)	9.68	4.04
Trial 2 (s)	8.12	4.44
Trial 3 (s)	10.84	4.12
Mean (s)	9.55	4.20
Std. Dev. (s)	1.364893	0.211660105

In this case, when the temperature of the object is higher, it allows the solute to dissolve in greater amounts. Since KI is of a greater density than water itself, greater levels of dissolution will increase the overall density of the solution. Thus the rate of sinking of an object in this solution should decrease. This is observed with the Graphite piece.

3.3. Evaluation

One alternate explanation for the above phenomenon was that the heat transfer actually generated convection currents which pushed up the piece of graphite. To test if this was the case, the setup was repeated with a solution without any excess solute so there wouldn't be an increase in the levels of dissolution. By right, if the cause were convection, the same phenomenon should occur. However, in this case the heated piece of graphite did not experience any significant decrease in velocity.

It is worth noting that if the difference in the temperature is less significant, the deviation from these results may mask the small difference and thus more accurate equipment will have to be used.

4. Conclusions

To conclude, this experiment has shown that the effect of localized heat transfer on the sinking of an object can allow us to find the temperature of the object. This process will from now on be called Double-dipping.

Double-dipping has various advantages and disadvantages. First of all, as previously mentioned, Double dipping is instantaneous. In this case we measured the velocity of the graphite over a short distance but the process was not. However, with the application of an accelerometer it should be possible to find the instantaneous velocity.

Also, Double-dipping does not require geometric parameters because you are checking against a fixed velocity calibrated with the same object previously just at a different temperature.

Most importantly, as compared to calorimetry, Double-dipping utilizes a different process and the required measurements are different. This allows it to be used in cases in which the requirements for DSC and other complex forms or calorimetry have not been met.

At the same time, however, the biggest disadvantage of Double dipping is that you can only check against a previously set benchmark, although it may also be possible to set multiple benchmarks so as to roughly gauge the exact temperature

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