Calculus Based Physics 1: LAB

PHYS 2110 WA

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Experiment 9: The Joule Heat

Groups:

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**Objective:**

The objective of this lab is to verify that **1 calorie is equal to 4.186 Joules.**

**Equipment:**

A computer with internet connection, paper, pencil, and calculator (ti-84 plus CE, ti-30sx II)

**Theory:**

It has previously been verified by many scientists and experiments that when **1 calorie of heat energy** is converted to **mechanical or electric work, 4.186 J** or work or energy is generated and vice versa.

***1 Cal. = 4.186 J***

The heating element in a calorimeter can be connected to a power source for a certain period of time during which electric work (energy) causes an increase in the temperature of the liquid in the calorimeter. The result of which is the conversion of electric work to heat energy. Calculating the energy that was delivered to the calorimeter, the formula for power can be applied:

**P = W / t or W = P \* t**

Since electric power is  **P = VI,** the above equation that gives electric energy consumption becomes:

**W = Vit (1)**

On one hand, by measuring the applied ***applied voltage V, the current I, and the consumption time t,*** the electric energy delivered to the calorimeter can be calculated from the formula **(1)**.

One the other hand, by measuring the initial and final temperatures of the calorimeter and other masses such as the water, container, and heating elements, the amount of heat that is generated can be calculated by using formula **(2)** or **(3)**. The specific heats of the elements involved are also required for the heat calculations.

***Qtotal = Qwater + Qcontainer + Qelement.***

Note that the masses of the container and heating elements are small and at the same time their specific heats are also small compared to what the heat of the water has. Therefore, the calculated values for *Qcontainer and Qelement* can be considered negligible compared to the *Qwater.*

**Qtotal = Qwater = Q (2)**

In terms of the water mass **M,** specific heat (c), Ti, and Tf the absorbed heat becomes:

**Q = MwCw (Tf – Ti) (3)**

The final equation (3) is used to calculate the energy, in calories, that the water absorbed because of the electric energy delivered to the heating elements, in joules. The ***calorie and joule values*** *can then be calculated from the equations (1) & (3) in order to determine the # of joules that one calorie can generate and vice versa.*

**Procedure:**

The virtual applet contained a set up of a thermometer, calorimeter, ammeter, and a voltmeter that was connected to a power source. The power source was connected to the heating element ***in series*** with an ammeter.

For the lab, it was assumed that the “***the heating element was inside a thermally well-insulated container with a certain amount of water in it.”***

For each case conducted in the lab, the volume of water was then changed for 5 different experiments. The voltage settings were also changed with each experiment case. The initial temperature of the water was recorded before starting the power source.

The water was heating long enough such that the temperature increased by at least 10 degrees celsius. Then the power was turned off and the values for voltage, current, and final temperature were recorded.

The Watts (Joules) and Specific heat were then measured and compared to the accepted value of 4.186 joules. The measured and accepted values were then calculated in the percent error.

**Data:**

**Given:**

The specific heat of water: C = 1 cal/(gr degrees celsius).

**(W/Q)accepted  = 4.186 J/cal**

**Measured: Mw, Ti, Tf, V, I, and t**

|  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Case** | **Water Mass**  **(grams)** | **Ti**  **Celsius** | **Tf**  **Celsius** | **V**  **Volts** | **I**  **Amps** | **t**  **sec.** | **W =**  **Vit**  **(j)** | **Q =**  **McΔt**  **Calorie** | **W/Q**  **Meas.**  **J/cal** | **W/Q**  **Accept.**  **J/cal** | **% Error** |
| **1** | **250** | **14.4** | **24.4** | **103** | **6** | **17** | **10506** | **2000** | **4.202** | **4.186** | **.382** |
| **2** | **404** | **11.8** | **22.2** | **105** | **8** | **21** | **17640** | **4101.6** | **4.300** | **4.186** | **2.72** |
| **3** | **224** | **12.0** | **21.3** | **84** | **6** | **17** | **8568** | **2083.2** | **4.113** | **4.186** | **1.74** |
| **4** | **229** | **12.2** | **22.4** | **84** | **6** | **20** | **10080** | **2335.8** | **4.315** | **4.186** | **3.08** |
| **5** | **365** | **11.9** | **22.0** | **105** | **8** | **19** | **15960** | **3686.5** | **4.330** | **4.186** | **3.44** |

**Calculations:**

Using equations (1) and (3) from the theory section of the lab report, the W, Q, and W/Q of case 1 was calculated as:

Case 1 Values: V = 103, I = 6, t = 17, Ti = 14.4, Tf = 24.4.

W = 103 \* 6 \* 17 = 10506 joules

Q = 250(24.4 – 14.4) = 2500 calories

W/Q measured = 10506Joules/2500Calories = 4.202 J/Cal

**Comparison of the Results:**

Applying the percent error formula of Accepted – Measured / (Accepted) X 100 = %

Case 1: 4.202 J/Cal – 4.186 J/Cal = 0.016

0.016 / 4.186 = 0.003822…

0.003822 X 100 = .382 %

**Conclusion:**

The objective of this lab was to verify that **1 Calorie = 4.186 Joules.** Using data gathered by the 5 cases and accounting for possible human error. We can say that 1 calorie is around 4.186 joules, with the percent error of the lab ranging from .3 – 3% error range.

**Discussion:**

The percent error being higher than usually could be due to human error. When observing initial and final temperatures, the thermometer would spike and go between higher and lower decimal values for a few seconds.

Another possible reason for percent error in this lab would be the user stopping the time a few milliseconds before or after the desired + 10 degrees celsius temperature was reached.

However these human errors still yielded low percent errors.