COVER PAGE, ABSTRACT 1.5

RESULTS 3.0

ANALYSIS 3.0

TOTAL 7.5/10

LABORATORY REPORT

GROUP NUMBER: W3

EXPERIMENT NUMBER: 6

TITLE: *Calorimetry: Heat of Combustion of Sucrose*

DATE SUBMITTED: Friday, February 17, 2000

ROLE ASSIGNMENTS

ROLE	GROUP MEMBER
FACILITATOR	Anna Lipski
TIME & TASK KEEPER	Alice Wu
SCRIBE	Chris Hack
PRESENTER	David Frerichs

ABSTRACT

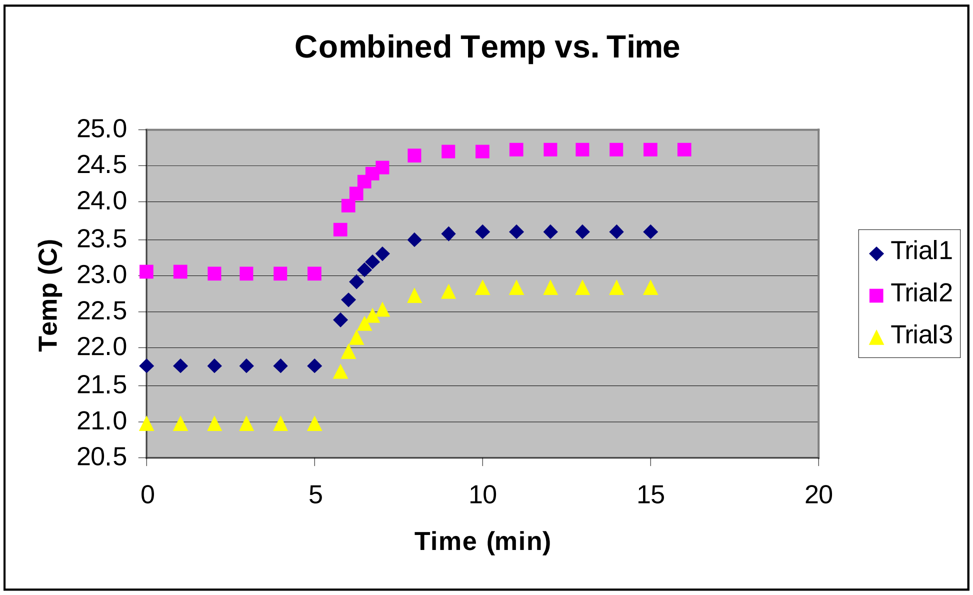
The heat of combustion of sucrose was investigated using Parr 1341 Plain Oxygen Bomb Calorimeter. Three trials were conducted and the average heat of combustion was 1325.59±14.8 (IS THIS THE STANDARD DEVIATION? OR CONFIDENCE LIMITS? OR UNCERTAINTY? YOU NEED TO IDENTIFY WHAT IT IS.) kcal/mol. To determine the heat of combustion, a graph of time versus temperature rise of the water in the calorimeter after combustion of the sucrose was constructed. The temperature rise was calculated and adjusted for the temperature rise before and after each trial; the gross heat of combustion was determined using the given W for the Parr Bomb (energy equivalent of the calorimeter determined by standardization). Additionally, errors from

acidic side reactions and from the energy consumed by the fuse wire burning were accounted for. The three trials were precise because they were all within ±64.67 kcal/mol of the mean – the acceptable range defined by the 95% confidence interval. Heat of combustion as determined experimentally is 1.7% below the literature value (YOU SHOULD CITE THE REFERENCE HERE) of 1348.8 kcal/mol.

RESULTS

YOU SHOULD HAVE SOME TEXT BEFORE SHOWING TABLES OR FIGURES, EXPLAINING WHAT YOU FOUND.

Figure 1. Trial Results – Combined Temperature vs. Time Graph for 3 Trials



The graphs (YOU MEAN FIGURE 1) reveal the expected trend (THIS IS AWKWARD – YOU MEAN THEY SHOW THE EXPERIMENTALLY MEASURED TEMPERATURE RISE) for temperature vs. time for the Parr Bomb. Note that the initial temperature in trials 1, 2, and 3, (21.762 ^{o}C, 23.044 ^{o}C, and 20.971 ^{o}C, respectively) was not carefully regulated – thus the rise in temperature occurred over different temperature ranges (SOMEONE KEPT OPENING THE WINDOW? DO YOU THINK THAT FLUCTUATIONS IN ROOM TEPERATURE COULD HAVE AFFECTED YOUR RESULTS?). The thermometer was adjusted (YOU MEAN THE THERMOMETER READING WAS ADJUSTED) according to correction factors provided by the manufacturer.

In order to determine the quantities needed to compute the temperature rise correction,

$$t = t_c - t_a - r_1(b-a) - r_2(c-b) \qquad \text{(Eq. 1)}$$

the temperature vs. time graph for each trial was carefully analyzed. Each variable was read from the temperature vs. time curves for trials 1, 2, and 3 and gave corrected temperature rises of 1.832 ^{o}C, 1.696 ^{o}C, 1.864 ^{o}C, respectively.

Table 1. Uncertainties in the Calculation of Heat of Combustion[1]

Quantity	Units	Apparatus	Uncertainty (+)
a	sec	clock	1
b	sec	clock	1
c	sec	clock	1
ta	deg. C	thermometer	0.01
tc	deg. C	thermometer	0.01
r1	(deg. C)/min.	thermometer	0.01
r2	(deg. C)/min.	thermometer	0.01
c1	mL	burette	0.05
c2	% sulfur	NA	0
c3	cm wire	ruler	0.05
W	cal/(deg. C)	bomb calorimeter	0.50%
m	g	balance	0.0001

Due to the complexity of the apparatus, many sources of error existed as shown in the table above.
YOU NEED TO INTRODUCE THE TABLES WITH SOME TEXT – SAY WHAT THEY SHOW. REFER TO TABLES BY NAME – TABLE 1, 2 ETC. YOU DO NOT REFER TO TABLE 2 AT ALL.

Table 2. Calculated Heat of Combustion of Sucrose

Trial #	Heat of combustion (kcal/mole)	Uncertainty (± kcal/mol)	% error
Literature	1348.8	0.43	NA
1	1325.64	14.5	1.7
2	1299.54	15.4	3.6
3	1351.60	14.6	0.2
Avg.	1325.59	14.8	1.7

Measured heats of combustion were within ± 5% of the literature value for sucrose. The experimental average heat of combustion was 1325.59±14.8 kcal/mol, which is an error of 1.7% below the literature value (CITE THE REFERENCE) AS SHOWN ABOVE IN TABLE 2. IT IS CONVENTIONAL TO ALSO INCLUDE THE STANDARD DEVIATION WHEN YOU REPORT A MEAN VALUE.

---

[1] For a full listing of the meaning of each of the 'quantity' variables, see the Experiment 6 Appendix in the *Bioengineering Laboratory Manual* for Spring 2000.

ANALYSIS

The 95% confidence interval for the three trials can be computed using the formula

$$\mu \pm (ts/n^{.5}) \qquad \text{(Eq. 3)}$$

for the confidence interval around a mean. Applying this formula reveals that the heat of combustion of sucrose is 1325.59 ± (4.303*26.03)/$3^{.5}$, (DID YOU USE THE STANDARD DEVIATION FOR THIS CALCULATION? YOU DO NOT GIVE THE STANDARD DEVIATION ANYWHERE IN YOUR RESULTS) or 1325.59 ± 64.67 kcal/mol—in other words, the best experimental value should fall within 64.67 kcal/mol of the mean. This is true in this experiment. The value for trial 1, 1325.64 kcal/mol, is nearly equal to the mean of 1325.59 kcal/mol, and the values for trials 2 (1351.60 kcal/mol) and 3 (1299.54 kcal/mol) both lie WITHIN one standard deviation from the mean (2 is above, 3 is below the literature value WHAT IS THE LITERATURE VALUE? YOU NEED TO CITE THE REFERENCE.). All of the trials are within the ±64.67 kcal/mol range of the confidence interval, so they are neither significantly different from each other, nor significantly different from the confidence interval. Therefore, the three trials can be deemed as precise by evaluating them from the statistics provided in the 95% confidence test. However, they were not highly accurate. The literature value for the heat of combustion of sucrose is 1348.8 kcal/mol (WHAT IS THE REFERENCE?). The trial 3 value of 1351.60 ± 14.6 (YOU SHOULD INDICATE THAT THIS IS THE UNCERTAINTY – IT IS MORE CUSTOMARY TO USE THE STANDARD DEVIATION) kcal/mol is accurate. But the values for trials 1 and 2 are further away from the literature value than their respective acceptable uncertainties of 14.5 and 15.4 kcal/mol allow, and are therefore inaccurate (reasons for inaccuracy are discussed below).

In order to calculate the heat of combustion for sucrose, the temperature rise was first corrected using Equation 1. Since r_1 and r_2 were both equal to zero for trials 1 and 3, and in trial 2, r_1 = -.002 and r_2 = 0, error in the last two terms of the temperature correction equation can be dismissed as having no significant effect on the measured heat of combustion of sucrose. This includes quantities a, b, c, r_1, and r_2 (see Table 1). However, the first two terms, t_a and t_c, are not multiplied by zero, and therefore must be taken into account as possible sources of error in the heat of combustion. Possible error for each term is ± 0.01 ^{o}C. Adding these two gives a maximum error of ± 0.02 in the corrected temperature rise.

Proceeding along a similar line of analysis for the heat of combustion equation,

$$H_g = (tW - e_1 - e_2 - e_3)/m \qquad \text{(Eq. 2)}$$

reveals that the ± 0.02 ^{o}C error in temperature is multiplied by W, which is equal to 2426 cal/^{o}C. This gives a maximum error of ± 48.52 cal/gm. Unit conversion gives an uncertainty of ± 16.6 kcal/mol for each trial. This number is adjusted to each specific trial by dividing by the mass of the sample, which gives uncertainties of 14.5, 15.4, and

14.6 for trials 1, 2, and 3. $E_{1,}$ e_2, and e_3 for each trial are less than 20 calories, so they do not even have an effect on any significant digit in ±16.6 kcal.

One source of uncertainty that likely affected accuracy and precision was parallax error that resulted from reading the thermometer incorrectly. Instead of pushing the magnifying glass against the edge of the thermometer and adjusting his head position to focus, the person taking data for the group moved the magnifier away from the thermometer and then took the readings. This flaw in experimental procedure was subsequently measured and shown to increase uncertainty in both t_a and t_c to ± 0.03 ^oC each. This doubles the total uncertainty to ± 0.06 ^oC. Plugging this into equation 2 yields potential uncertainties of 43.6 kcal/mol for trial 1, 49.9 kcal/mol for trial 2, and 44.0 kcal/mol. With this experimental error accounted for, all three trials agree with the literature value within their accepted uncertainties. This error could be eliminated very easily in future by practicing reading temperatures with the magnifying glass before actually beginning to take measurements, or by fastening the magnifier to the thermometer when taking readings.

In conclusion, calorimetry of three samples of sucrose pellets was conducted using the non-adiabatic Parr Bomb Calorimeter. Data was collected correlating the rise in temperature of the water contained in the calorimeter with time. Heat of combustion of sucrose was determined using equations which take into account errors arising from acidic side reactions, energy consumed with fuse wire, and from the temperature changes before and after the reaction. Data collected for the three trials was averaged, yielding an experimental heat of combustion of 1325.59 ± 64.67 (WHAT IS THIS? THE CONFIDENCE LIMIT? YOU NEED TO IDENTIFY WHAT IT IS.) kcal/mol. This is below the literature value 1348.8 kcal/mol by 1.7%. Taking into account the uncertainty resulting from parallax error, this places the literature value within the accepted range of the experimental. The experimental and educational objectives were both met. Group members performed calorimetry experiments to determine the heat of combustion of sucrose. In addition, group members were introduced to thermochemistry and the use of the Parr Bomb Calorimeter.

YOU DO NOT SPECIFICALLY CITE THE REFERENCES ANYWHERE IN YOUR REPORT.

REFERENCES

1. Ponomarev and Migarskaya, Heats of combustion of some amino-acids, Russ. J. Phys.Chem. (Engl. Transl.), 1960, 34, 1182-1183.

2. Litt, Mitchell. "Calorimetry: Heat of Combustion of Sucrose." *Bioengineering Laboratory Manual*. pp. 1-7, 2000

3. *Operating Instructions* for 1108 Oxygen Combustion Bomb (205M), Oxygen Bomb Calorimeter (204M), Pellet Press, and Mercurial Thermometer (211M). Parr Instrument Co., Moline, IL.