Heat of Combustion: Sugar

The heat of combustion ($\Delta H_{\text{comb}}$) is the heat of reaction for the complete burning (reacting with O$_2$) of one mole of a substance to form CO$_2$ and H$_2$O. Calorimetry experiments that measure the heat of combustion can be performed at constant volume using a device called a bomb calorimeter. In a bomb calorimeter a sample is burned in a constant-volume chamber in the presence of oxygen at high pressure. The heat that is released warms the water surrounding the chamber. By measuring the temperature increase of the water, it is possible to calculate the quantity of heat released during the combustion reaction. In this assignment you will calculate the heat of combustion of sugar (sucrose, C$_{12}$H$_{22}$O$_{11}$). The calorimeter has already been calibrated by combusting benzoic acid.

1. Start Virtual ChemLab and select Heat of Combustion: Sugar from the list of assignments. The lab will open in the Calorimetry laboratory with the bomb calorimeter out and disassembled and with a sample of sugar in the calorimeter cup on the balance. The balance has already been tared.

2. Click on the Lab Book to open it.

3. Record the mass of the sugar sample from the balance. If you cannot read it click on the Balance area to zoom in, record the mass in the data table below and return to the laboratory.

4. Double-click the following (in numerical order) to assemble the calorimeter: (1) the cup on the balance pan, (2) the bomb head, (3) the screw cap, and (4) the bomb. Click the calorimeter lid to close it. Combustion experiments can take a considerable length of time. Click the clock on the wall labeled Accelerate to accelerate the laboratory time.

5. Click the bomb control panel and the plot window to bring them to the front. Click on the Save button to save data to the lab book. Allow the graph to proceed for 20-30 seconds to establish a baseline temperature.

6. Click Ignite and observe the graph. When the temperature has leveled off (up to 5 minutes of laboratory time), click Stop. A blue data link will appear in the lab book. Click the blue data link to view the collected data. Record the temperature before and after ignition of the sugar sample in the data table.

<table>
<thead>
<tr>
<th>Data Table</th>
<th>sucrose (C$<em>{12}$H$</em>{22}$O$_{11}$)</th>
</tr>
</thead>
<tbody>
<tr>
<td>mass of sample (g)</td>
<td></td>
</tr>
<tr>
<td>initial temperature (°C)</td>
<td></td>
</tr>
<tr>
<td>final temperature (°C)</td>
<td></td>
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</tbody>
</table>

7. Write a complete balanced chemical equation for the combustion of sucrose. __________________________________________

8. Calculate $\Delta T$ for the water using $\Delta T = |T_f - T_i|$. __________________________________________
9. **Calculate the moles of sucrose in the sample** ($MW_{sucrose} = 342.3 \text{ g/mol}$).

10. $\Delta H_{\text{comb}}$ for sucrose can be calculated using $\Delta H_{\text{comb}} = \left( C_{\text{system}} \Delta T \right)/n$, where $n$ is the moles of sucrose in the sample and $C_{\text{system}}$ is the heat capacity of the calorimetric system.

    *Use 10.310 kJ/K for $C_{\text{system}}$ and calculate the heat of combustion, in kJ/mol, for sucrose.*

11. **If the accepted value for the heat of combustion for sugar is 5639 kJ/mol calculate the percent error.**

    \[
    \% \, \text{Error} = \left| \frac{\text{your answer} - \text{accepted answer}}{\text{accepted answer}} \right| \times 100
    \]

    % Error =

    This experiment does not consider that all of the conditions are standard state conditions; therefore, you are calculating $\Delta H_{\text{comb}}$ **not** $\Delta H^\circ_{\text{comb}}$. 