SI Chemistry - Full Discipline Demo

Digital Calorimetry and Caloric Content - Beyond Labz

Final Report - Answer Guide

Institution	Science Interactive University
Session	SI Chemistry - Full Discipline Demo
Course	SI Chemistry - Full Discipline Demo
Instructor	Sales SI Demo

Test Your Knowledge

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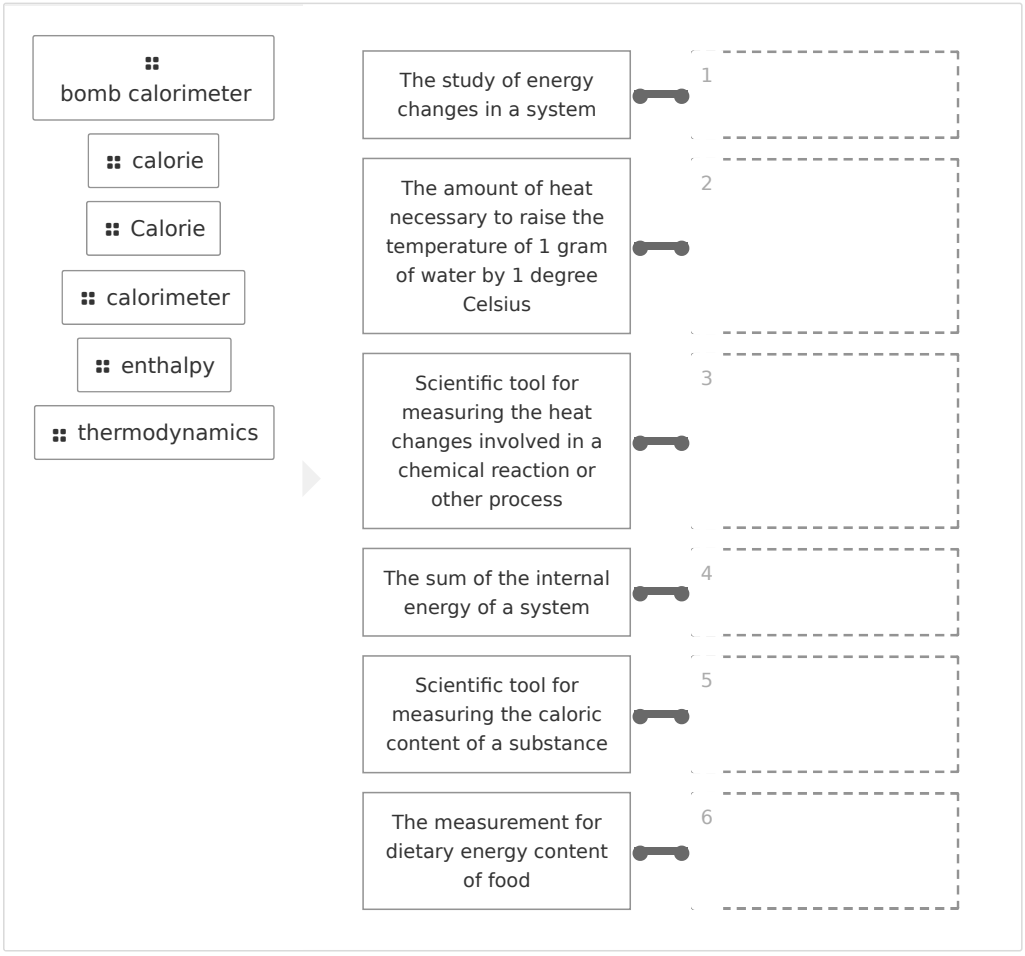
Match each term to the best description.



Correct answers:

1 thermodynamics 2 calorie 3 calorimeter 4 enthalpy

5 bomb calorimeter 6 Calorie

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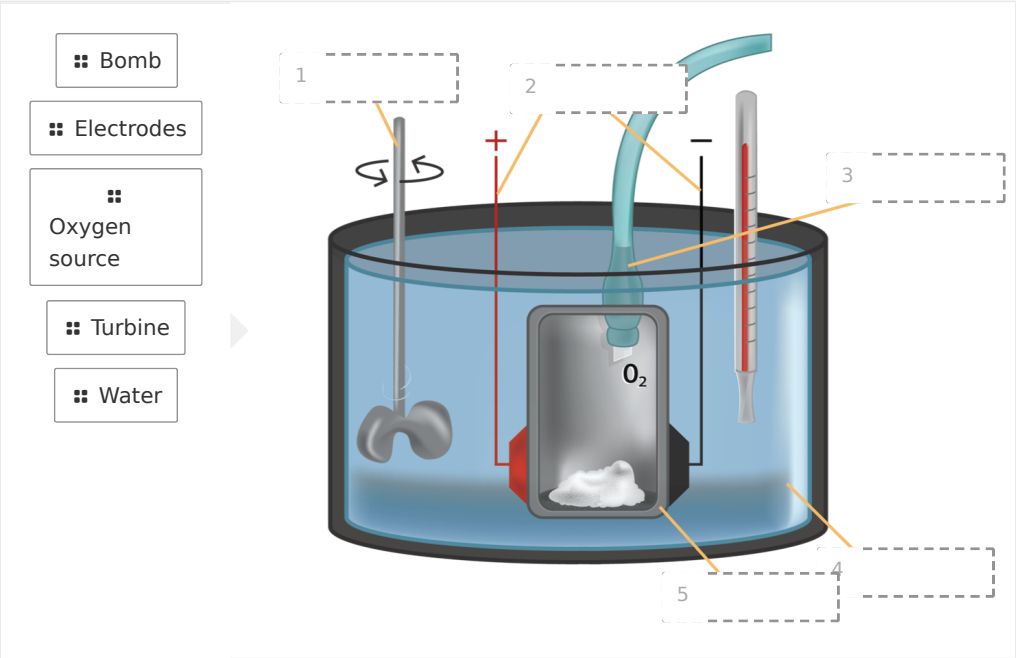
Label the image of the bomb calorimeter.



Correct answers:

1 Turbine 2 Electrodes 3 Oxygen source 4 Water 5 Bomb

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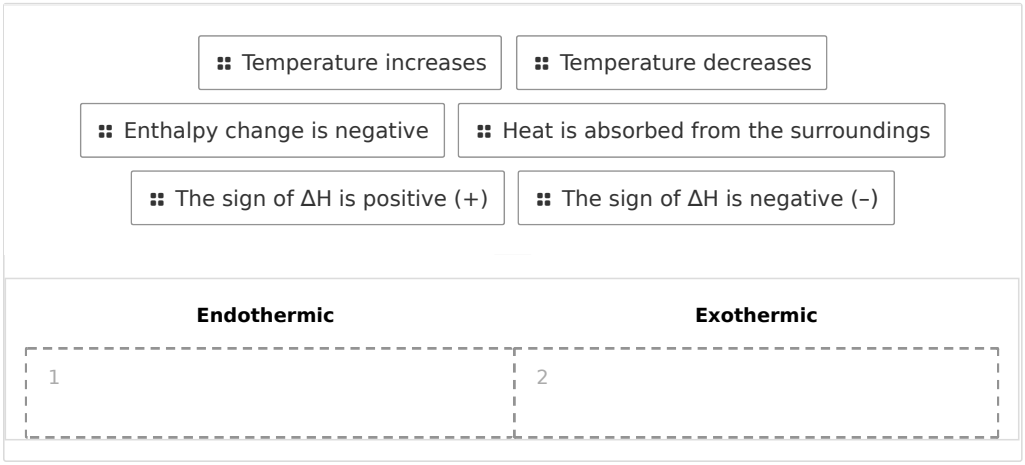
Categorize each statement as being representative of an exothermic or endothermic reaction.



Correct answers:

1 Temperature decreases The sign of ΔH is positive (+)

Heat is absorbed from the surroundings

2 Temperature increases Enthalpy change is negative

The sign of ΔH is negative (–)

Exploration

When a reaction is exothermic, the temperature of the surrounding environment _____.

- increases ✔
- decreases
- stays the same
- could either increase or decrease

A bomb calorimeter can be used to measure the caloric content of foods.

- True ✔
- False

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A calorie is the amount of heat necessary to raise the temperature of _____.

- 1 gram of water by 1 degree Fahrenheit (°F)
- 1 gram of mercury by 1 degree Celsius (°C)
- 1 gram of mercury by 10 degrees Celsius (°C)
- 1 gram of water by 1 degree Celsius (°C) ✔

Exercise 1

Calculate the percent error between your calculated ΔH_{comb} values from steps 48 and 49 to the actual values of ΔH_{comb} for fat or sugar using the following equation. The actual values of ΔH_{comb} are −30 038 kJ/mol (fat) and −5639 kJ/mol (sugar).

$$\text{percent error} = \left|\frac{calculated - actual}{actual}\right| \times 100\%$$

Ex:

Fat: 0.20%

Sugar: 0.071%

Correct calculations should produce results very near the true value, >1%

Was the combustion of sugar endothermic or exothermic? Explain how this reaction was measured in the bomb calorimeter in your response.

Exothermic: The burning of the sugar released heat which warmed the water and caused the temperature increase.

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Suppose the temperature measured in a calorimeter decreased over the course of a reaction. Was this reaction endothermic or exothermic? How do you know?

0 / 10000 Word Limit

Kilojoules can be converted to Calories using the following conversion:

$$1\ \text{Calorie} = 4.184\ \text{kJ}$$

Use your values of *q* from Trial 1 in the first column of Tables 1 and 2, calculate how many Calories were in your samples of fat and sugar. Note that Calories are only presented as positive numbers. Which food source would be more effective for a sustained fuel?

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Data Table 1: Calorimetry of Fat
(SAMPLE ANSWER BELOW)

	Trial 1	**Trial 2**	**Trial 3**	
mass fat (g)	0.9436	0.9216	0.8565	
$T_{initial}$ (°C)	25.000	25.000	25.000	
T_{max} (°C)	28.451	28.374	28.135	
ΔT (°C)	3.451	3.374	3.135	
q (kJ)	-35.58	-34.79	-32.32	
moles fat	0.001183	0.001155	0.001074	
ΔH_{comb} (kJ/mol)	-30 080	-30 120	-30 090	Average:-30 097

Data Table 2: Calorimetry of Sugar
(SAMPLE ANSWER BELOW)

	Trial 1	**Trial 2**	**Trial 3**	
mass sugar (g)	0.9749	1.0297	0.9505	
$T_{initial}$ (°C)	25.000	25.000	25.000	
T_{max} (°C)	26.559	26.646	26.520	
ΔT (°C)	1.559	1.646	1.520	
q (kJ)	-16.07	-16.97	-15.67	
moles sugar	0.002848	0.003008	0.002777	
Typesetting math: 100%	-5 643	-5 642	-5 643	Average:-5 643

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ΔH_{comb} (kJ/mol)				

Image 1: Graph of Calorimeter Temperatures for Fat
(SAMPLE ANSWER BELOW)

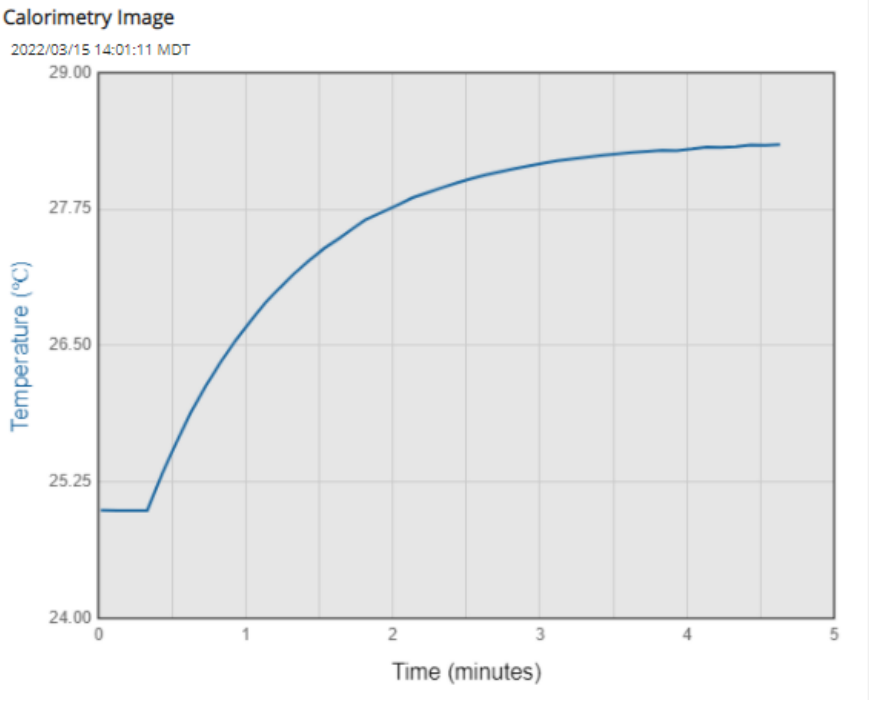

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Image 2: Graph of Calorimeter Temperatures for Fat
(SAMPLE ANSWER BELOW)

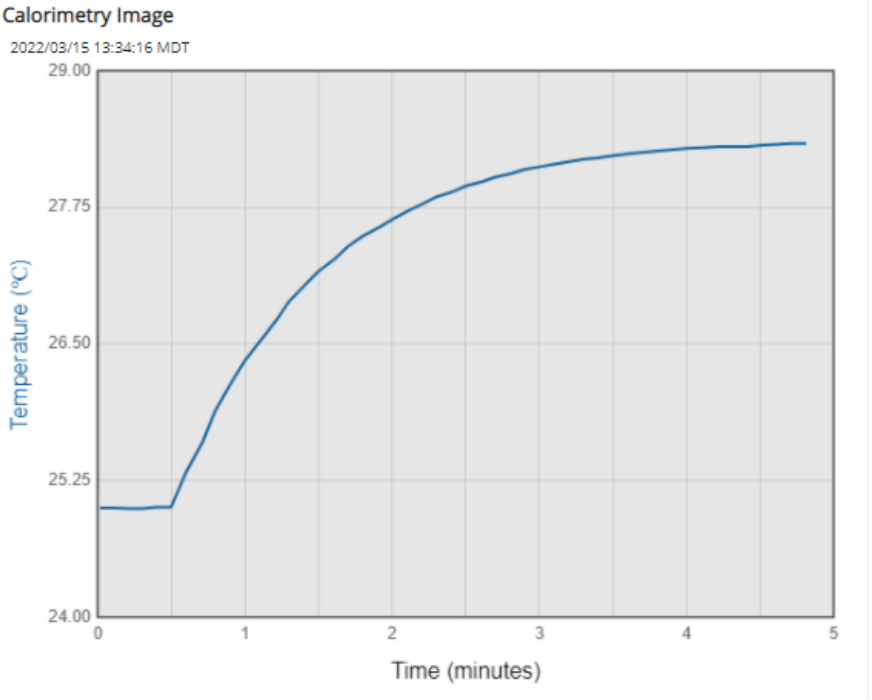

Image 3: Graph of Calorimeter Temperatures for Fat
(SAMPLE ANSWER BELOW)

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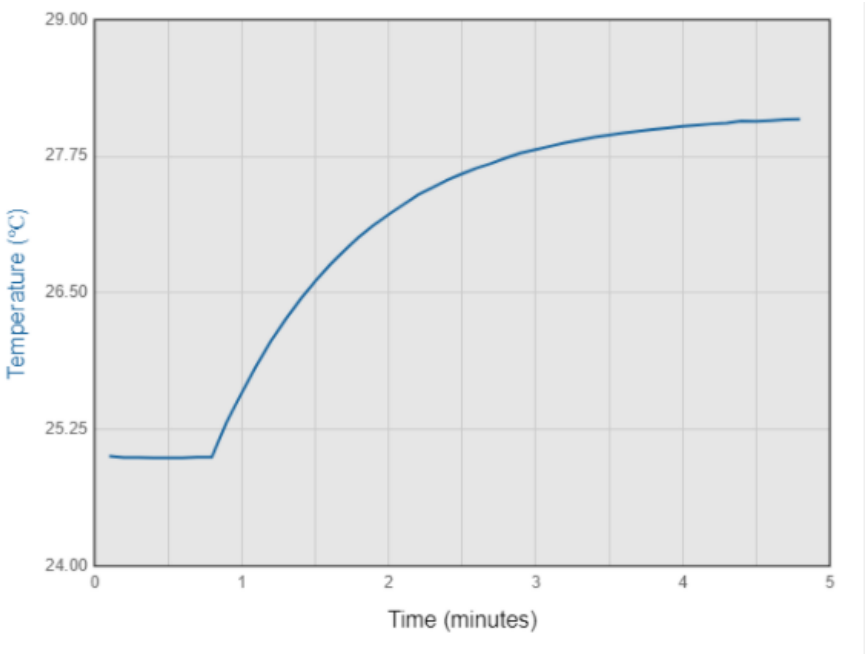
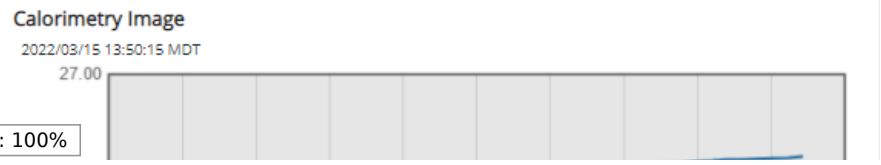


Image 4: Graph of Calorimeter Temperatures for Sugar

(SAMPLE ANSWER BELOW)



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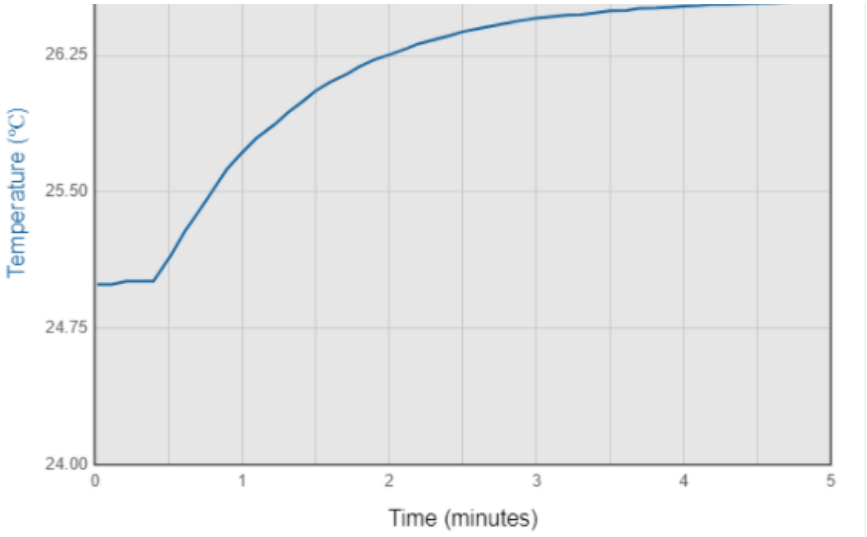
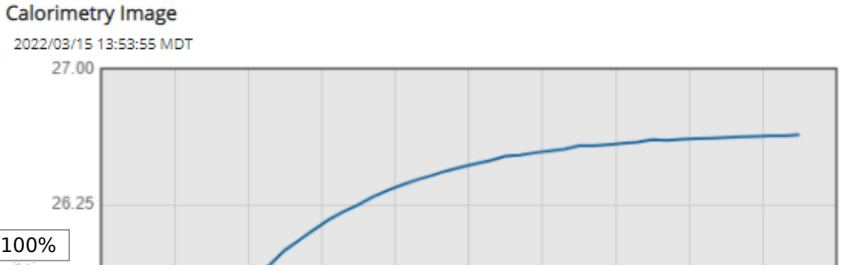


Image 5: Graph of Calorimeter Temperatures for Sugar

(SAMPLE ANSWER BELOW)



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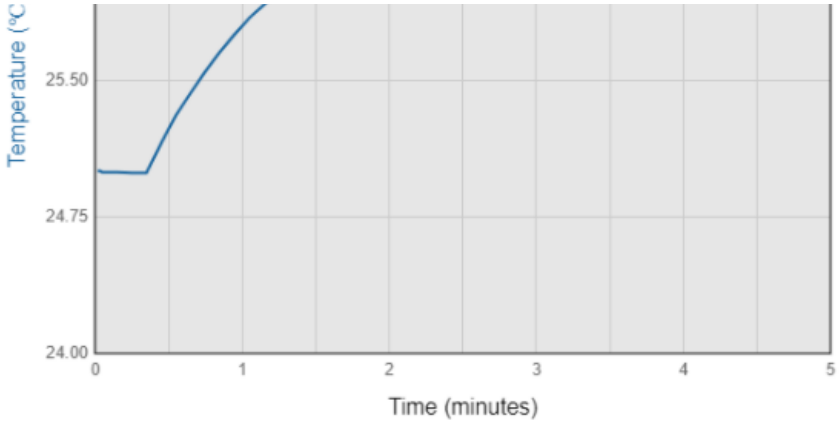
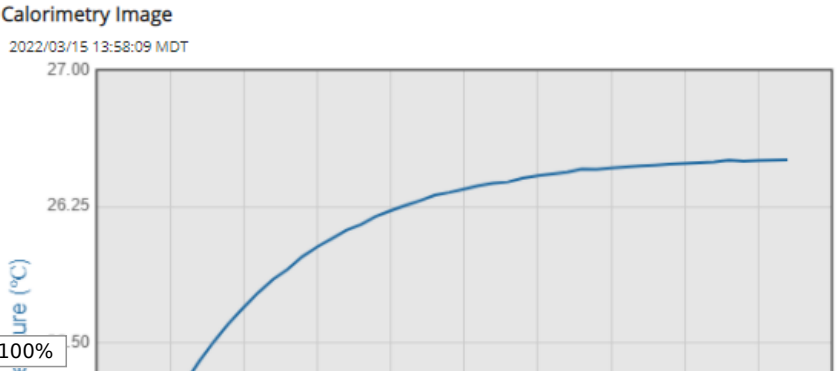


Image 6: Graph of Calorimeter Temperatures for Sugar

(SAMPLE ANSWER BELOW)



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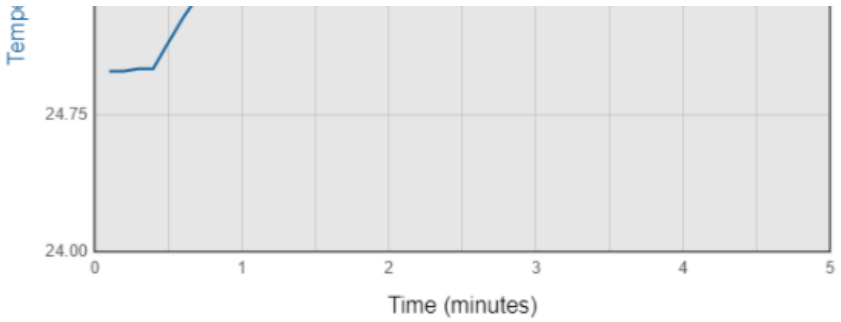

Competency Review

A calorie is _____.

- a unit that is used to show how nutritious certain foods are
- the amount of heat energy it takes to raise the temperature of 1 gram of water 1 degree Celsius ✔
- a vital nutrient that all animals require for survival
- the specific heat of any substance

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A calorimeter is used to measure _____ involved in chemical reactions or other processes.

- heat changes ✔
- known quantities of water
- dietary Calories
- nutrient absorption

Data concerning the _____ must be collected in order to determine the caloric content of food using a bomb calorimeter.

- change in water weight
- rate at which food burns
- change in water temperature ✔
- change in volume of water lost

In an exothermic reaction in a bomb calorimeter, the temperature change observed would _____.

- decrease because the heat flowing from the reactants to the surrounding water
- decrease because the heat is flowing from the surrounding water into the reactants
- increase because the heat is flowing from the reactants to the surrounding water ✔
- increase because the heat is flowing from the surrounding water into the reactants

_____ is/are the sum of the internal energy of a system.

- Enthalpy ✔
- Thermodynamics
- The heat of reaction
- Calories

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The chamber submerged in the water of the calorimeter containing the sample that will be combusted is called the _____.

- bomb ✔
- electrodes
- thermometer
- turbine

A bomb calorimeter has a heat capacity ($m \cdot C$) of 21.610 kJ/°C. If the temperature change for 0.00512 moles of a substance is an increase of 12.532 °C, the ΔH_{comb} is _____.

$$q = -m \cdot C \cdot \Delta T$$

$$\Delta H_{comb} = \frac{q}{moles}$$

- 271 kJ/mol
- –271 kJ/mol
- 529 kJ/mol
- –529 kJ/mol ✔

If the value of *q* for 0.0015 moles of a substance –51.62 kJ, there are _____ Calories present in that sample. Recall that there are 4.184 kJ in a Calorie.

- 12.34 ✔
- –12.34
- 8225
- –8225

Extension Questions

Explain how the following experimental errors affect the calculation of the how many kJ/mol a food item contains. Be specific as to whether the final value will be higher or lower than if the error had not been made.

a. The student misread the scale and recorded 10.10 g for the mass of the food instead of 1.010 g.

b. Part of the food sample was not combusted, but the mass of what remained was not determined.

c. The thermometer got stuck in its holster while the combustion was occurring, and the final temperature was read with the thermometer in the air above the water rather than in the water.

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a. An artificially high mass of sample would make it appear that the amount of energy released was less than it would have been if the sample was truly larger, thus giving an artificially low value of kJ/mol.

b. Not combusting the whole sample would not heat the water as much as if it had been fully combusted. If that difference is not accounted for, the final calculation of kJ/mol would be artificially low.

c. The air above the water would likely also warm slightly as the water heated, but not as much as the water, yielding an artificially low final temperature. This results in a lower ΔT value, and thus an artificially low value of kJ/mol released.

The food we eat does not get "combusted" in our digestive process the way that the sugar and fat in this experiment was burned in the bomb calorimeter. Why are the energy measurements performed in related caloric measurements still a good way of conveying to consumers how much energy is stored in food? (SAMPLE ANSWER BELOW)

Our digestive process is a chemical reaction that creates the same products as the combustion process (water and carbon dioxide), it just uses enzymes and catalysis instead of heat to get there. As such, the energy released is the same either way. Heat release through combustion is therefore a very accurate way to quantify how much energy the body can obtain from different foods.

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