SI Chemistry - Full Discipline Demo

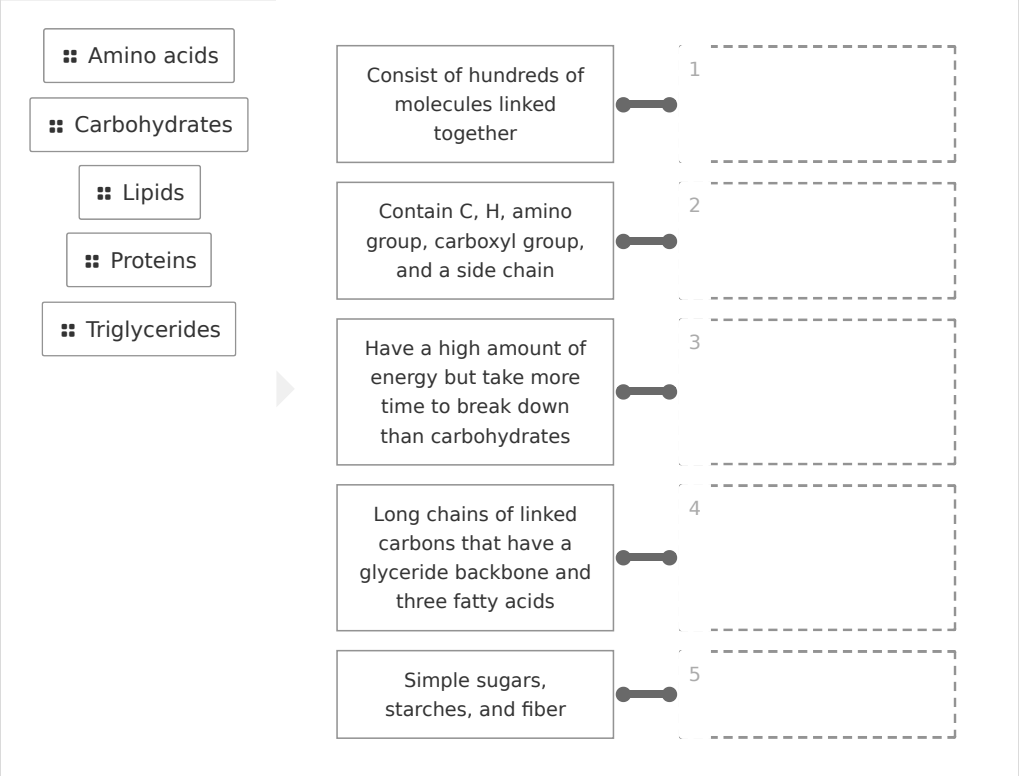
Caloric Content of Food

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

Match each term to the best description.



Correct answers:

1 Proteins 2 Amino acids 3 Lipids 4 Triglycerides

5 Carbohydrates

Use Atwater factors and the provided table to rank the snacks from highest number of calories to lowest number of calories.

Snack	Fat (g)	Carbohydrate (g)	Fiber (g)	Protein (g)
Pretzels	0	23	1	3
Potato chips	15	23	1	3
Graham crackers	3	24	1	2
Granola bar	3	17	1	1

≡ Graham crackers

1 **Correct answer:** Potato chips

≡ Granola bar

2 **Correct answer:** Graham crackers

≡ Potato chips

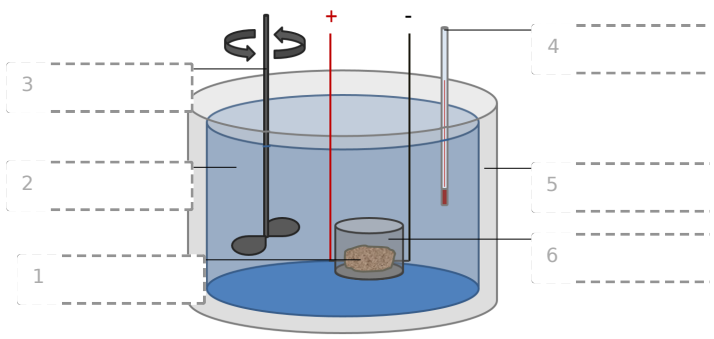
3 **Correct answer:** Pretzels

≡ Pretzels

4 **Correct answer:** Granola bar

Label the image of the bomb calorimeter.

Bomb
Outer chamber
Reactant
Thermometer
Turbine
Water



Correct answers:

1 Reactant 2 Water 3 Turbine 4 Thermometer

5 Outer chamber 6 Bomb

Match each term to the best description.

calorie (cal)
Dietary Calorie
Kilocalorie
Specific heat capacity

1,000 calories → 1
A unit of energy → 2
Energy released from food (also called kilocalories) → 3
Water is 1.00 cal/g°C → 4

Correct answers:

1 Kilocalorie 2 calorie (cal) 3 Dietary Calorie

4 Specific heat capacity

Exploration

A calorie is the amount of heat necessary to raise the temperature of one gram of water by one degree Celsius (°C).

- True ✔
- False

A bomb calorimeter is used to measure energy changes in reactions that occur at a constant pressure.

- True
- False ✔

Proteins are composed of hundreds of small molecules called _____.

- peptides
- amino acids ✔
- fiber
- nitrogen

Triglycerides are long chains of linked carbons that have a glycerol backbone and three fatty acids; they can be a component of lipids.

- True ✔
- False

There are thirty different types of amino acids that can be found in proteins.

- True
- False ✔

Lipids provide approximately _____ calories per gram.

- 4
- 5
- 8
- 9 ✔
- 11

Exercise 1

Compare the calorimeter that you built to a bomb calorimeter. How are they similar and different?

The calorimeter built by the student is still measuring the differences in temperature of water. However, the burned food is not surrounded by water – so much of the heat escapes into the open air. Additionally, the student-built calorimeter is a constant pressure calorimeter, while the bomb calorimeter is a constant volume calorimeter. Therefore, some of the energy released by the food burning is lost to the expansion of gas and is not absorbed by the water.

Based on your results, was this setup a good way to measure Calories as opposed to a bomb calorimeter? What types of experimental error may have occurred with this experiment? How might you design this setup differently if you had unlimited expenses for materials?

Since some of the heat given off by the burning food will be absorbed by the soda can and some more energy will escape into the air, only the remaining heat goes into heating the water. This means that the results we will get from this exercise will be lower than the estimated values. Designs may include setups such as a bomb calorimeter (no heat escapes).

Based on how each food burned, which food would be the best to use for a fuel that has a steady flame and might burn for a long time? What was the composition of this food (which macromolecule was it mostly composed of)? How does this relate to the way that the human body utilizes this type of macromolecule as fuel?

The walnut should have had a steady flame and should have burned for the longest time. The walnut is mostly composed of lipids, which burn at a slow, steady rate in the human body as well.

Although protein was part of the composition of the foods in this experiment, it was not the main macromolecule component of any of the foods. Why do you think a food consisting primarily of protein was omitted from these tests, based on what you learned about the way the fuel is "burned" in the body?

A food with the main component of protein was not used because the body typically uses free amino acids to build nrew proteins instead of using protein as fuel, and therefore protein is inefficiently utilized for energy in the human body and does not burn well.

Using your data, which food had the most amount of kilocalories per gram? Based on what you learned about the structure of each macromolecule, why is this true?

The walnut should have had the most Calories per gram. The walnut is mostly composed of fats, which are large molecules with many bonds that are broken when burned.

When you determined the amount of estimated Calories in the foods based on Atwater factors using the amounts of each macromolecule in the food, did you get the same number as what was listed as the amount of Calories per serving on the nutrition label? If not, why do you think there might be some discrepancy?

The students should not have gotten the same number. The nutrition labels are created using rounding, both for the amount of grams of each macromolecule in the food and also for the overall Calories.

Data Table 1: Mass of the Water
(SAMPLE ANSWER BELOW)

	Walnut	Marshmallow	Tortilla chip
Mass of the Water (g)	50.00	50.00	50.00

Data Table 2: Caloric Calculations
(SAMPLE ANSWER BELOW)

Food Item Description:	Walnut	Marshmallow (Jumbo)	Tortilla Chip
Mass of food, cup, and clip - initial (g)	6.88	12.26	6.84
Mass of food, cup, and clip - final (g)	5.03	11.41	5.22
Mass of burned food (g)	1.85	0.85	1.62
Observations of Flame (intensity, length of time burning, etc.)	Flame was steady, intense, slow, long burn	Intense flame, quick burn	Steady flame, not intense, slow burn
Water temp - initial °C	15.0	14.5	14.5
Water temp - final °C	71.0	26.2	44.2
Change in temp (ΔT) °C	56.0	11.7	29.7
Energy released (Q) (kcal)	2.81	0.58	1.48
Energy released per gram (Q/m) (kcal/g)	1.52	0.69	0.92
Energy Estimated on Package (kcal/g)	6.53	3.44	2.5
Percent Difference	124%	133%	93%
Determination of Calories according to Atwater Factors (kcal/g)	6.77	3.31	2.52

Photo 1: Nutritional Labels
(SAMPLE ANSWER BELOW)

Competency Review

What is a calorie?

- A unit of energy that is used to show how nutritious certain foods are
- The amount of energy in the form of heat that 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 capacity of water is _____.

- (g x °C)/1 cal
- °C/(g x 1 cal)
- 1 cal/(g x °C) ✔
- g/(1 cal x °C)

A bomb calorimeter is used to measure _____ in reactions that occur in a constant volume.

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

Monosaccharides are the smallest building blocks of sugars and have similar chemical compositions. Considering that simple sugars are a component of carbohydrates, what is the general chemical composition of monosaccharides?

- $C_m(H_2O)_n$ ✔
- $CO_n(NH_2)_n$
- $CH_3(CH_2)COOH$
- $NH_3(H_2O)_n$

Fats have a high amount of stored energy because _____.

- once ingested, they quickly and easily dissolve in the body making them readily accessible
- the hydrocarbon chains have many bonds that take time to break down ✔
- Fats are actually low in stored energy due to a lipid barrier that makes the breakdown of these molecules more difficult than other sources of energy

The primary difference between each amino acid is _____.

- the side chain (functional group) of the alpha carbon ✔
- the carboxyl group of the beta carbon
- polar amino acids contain nitrogen, while non-polar amino acids do not
- polar amino acids are able to form inter-protein disulfide bonds, while non-polar amino acids cannot

The primary use of ingested proteins in the body is to _____.

- be broken down into amino acids that are used to build proteins and nucleic acids within the body ✔
- be broken down to release energy and the unused components are recycled to build new proteins within the body
- interact with signaling molecules to trigger the building of muscle fibers
- be converted to starches or sugars, which are more readily accessible forms of energy

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

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

A scientist would compare data collected with a bomb calorimeter to accepted values of caloric content in a specific food by _____.

- describing the values listed on a nutrition label
- calculating the percent difference between the data collected and data on a nutrition label ✔
- recording detailed observations on the intensity and amount of flame produced

When using Atwater factors to determine the amount of calories from carbohydrates, it is necessary to subtract the fiber content, per unit of carbohydrate because _____.

- fiber cannot be broken down in the body, so it is not used for energy ✔
- fiber is loosely bound to carbohydrate molecules, and are cleaved immediately after ingestion
- fiber should not be subtracted from carbohydrates because the binding of these molecules is what allow them to be an accessible form of energy
- fiber and carbohydrates are not related

Extension Questions

Explain how the following experimental errors affect the final calculation of the kilocalories per gram for a food item. 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 110.3 g for the final mass of the beaker plus water instead of 101.3 g.

b. Part of the unburned marshmallow fell off before the final mass was determined.

c. The food would not keep burning and had to be relit several times.

d. The thermometer got stuck in the aluminum foil while the food was burning and the final temperature was made with the thermometer in the air above the water and not in the water.

(SAMPLE ANSWER BELOW)

a. Having an artificially high mass for the water would give a higher value for energy released (q) and a higher value for kilocalories per gram.

b. The final mass of the marshmallow would be too low, leading to a higher mass of burned marshmallow and a lower value for kilocalories per gram.

c. This scenario is likely to result in water that cooled and rewarmed several times leading to an artificially low final temperature. This results in a lower value for energy released (q) and a lower value for kilocalories per gram.

d. The air above the water would be warmer than the air in the room but not as warm as the water, yielding an artificially low final temperature. This results in a lower value for energy released (q) and a lower value for kilocalories per gram.