Lesson Title	Calorimetry
Length of Lesson	180 min (2 days)
Created By	David Wilson
Subject	AP Chemistry
Grade Level	10-12
State Standards	4 (d, e)
DOK Level	DOK 2 / DOK2
DOK Application	Explain and Describe
National Standards	K-12: Unifying Concepts and Processes / 9-12: B: Physical Science / 9-12: C: Life Science
Graduate Research Element	Calorimetry is a fundamental part of chemical research. My research group uses isothermal titration calorimetry to study the enthalpy changes resulting from protein-substrate interactions.

Student Learning Goal:

State Standards: (Chemistry)

4) Analyze the relationship between microscopic and macroscopic models of matter.

d. Explain the thermodynamics associated with physical and chemical concepts related to temperature, entropy, enthalpy, and heat energy. (DOK 2)

e. Describe and identify factors affecting the solution process, rates of reaction, and equilibrium. (DOK 2)

National Science Standards: (9-12)

Unifying Concepts and Processes:

As a result of activities in grades K-12, all students should develop understanding and abilities aligned with the following concepts and processes:

- Systems, order, and organization
- Evidence, models, and explanation
- Constancy, change, and measurement
- Evolution and equilibrium
- Form and function

B: Physical Science: Chemical Reactions

- Chemical reactions may release or consume energy. Some reactions such as the burning of fossil fuels release large amounts of energy by losing heat and by emitting light. Light can initiate many chemical reactions such as photosynthesis and the evolution of urban smog.

C: Life Science: Matter, Energy, and Organization in Living Systems

- The chemical bonds of food molecules contain energy. Energy is released when the bonds of food molecules are broken and new compounds with lower energy bonds are formed. Cells usually store this energy temporarily in phosphate bonds of a small high-energy compound called ATP.

Materials Needed (supplies, hand-outs, resources):
Be Careful and always read the Materials Safety Data Sheet (MSDS) written for chemicals you use. Federal Law requires the vendors of chemicals to provide MSDS sheets for all their chemicals

(All quantities specified here are for approximately one lab group.)

1) 2 styrofoam cups
2) 1 thermometer
3) 1styrofoam top for the Styrofoam cup
4) 1 graduated cylinder
5) Ammonium chloride
6) Sodium acetate
7) Mossy Zinc
8) 1 beaker
9) 1 ring stand with a test tube clamp, iron ring, and wire gauze
10) 1 large test tube
11) balance and weigh boats
12) Food: 1 SMALL marshmallow, 1/6th of a cheeto, 1 pea-sized piece of walnut, 1 corn chip, 1 potato chip

Lesson Performance Task/Assessment:
Students will

- Determine the specific heat of an unknown metal.
- Determine the heat of solution for a known salt.
- Determine the number of Calories (kcal) contained in certain foods.

Lesson Relevance to Performance Task and Students:
This lab is a calorimetry lab. The students are learning to perform thermodynamic calculations, and this lab will put those calculations into a meaningful perspective.

Anticipatory Set/Capture Interest:
I'll ask the students to guess how scientists determine the Calorie content of food. Then, I'll let them know that they will determine the Calorie content of certain foods in this lab. Then, I will explain how they will perform the lab. Also, they will have completed an "Advanced Study Assignment" the day before to give them practice at performing the calculations involved in this lab.

Guided Practice:
The first two portions of this lab will be performed on the first day under close supervision.

Independent Practice:
The second day, the third part of the lab (food Calories) will be done. The students will be expected to perform the required experiment on their own with less guidance from the teacher.

Remediation and/or Enrichment:
Remediation: Individual IEP.
Enrichment: Students will be asked to explain the results of their experiment based on the biomolecules present in each food. Then they will be asked to predict the Calorie content of other foods based on the biomolecules they are in those foods (i.e. vegetable oil, potato starch, soy burgers, etc.)

Check(s) for Understanding:
The students should be able to perform the required "Post-Lab" questions on their own.

Closure:
I will briefly ask the students to discuss the enrichment assignment, and I will relate their discussion to smart food choices and Michelle Obama's efforts to reform school cafeteria programs.

Possible Alternate Subject Integrations:
Biology. Nutrition is very important in biological systems.

Teacher Notes:
References:

1) CHE-106 Lab Manual used at The University of Southern Mississippi; Woodruff, Frank and Howell, J. Emory. Chemical Principles in the Laboratory. The University of Southern Mississippi. 2000. {This particular lab was copyrighted in 1975.}
2) CH 1211 Lab Manual used at Mississippi State University; Debra Mlsna. CH 1211 Lab Manual. 2011.

An Advanced Study Assignment, Lab Procedure, and Lab Background are attached.