Lesson Plan: How to Identify Materials via Calorimetry

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Lesson: How to Identify Materials via Calorimetry

Timeframe: 45 minutes

Target Audience: Introductory and general chemistry students

Materials needed: Whiteboard markers, slides with specific heats for common substances (**http://www.engineeringtoolbox.com/specific-heat-capacity-d_391.html**) such as water, iron, lead, and copper.

Objectives: After this lesson students will be able to...

Basic:

1. Define heat and draw a picture to illustrate its flow
2. Compute heat flow from/to a pure substance
3. Identify calorimetry as a useful tool to identify substances
4. Identify calorimetry as a way to measure heat flow
5. Recognize that the heat equation is used in calorimetry

Advanced:

1. Determine the identity of any pure substance using calorimetry
2. Efficiently process calorimetry data via calculations
3. Teach another student how to perform a calorimetry calculation and use it to identify an unknown pure substance

Background: This lesson is developed for chemistry students who are learning thermochemistry principles for the first time. Since calorimetry is a common tool used to identify energy content of substances (including food), it is an excellent way to introduce the ideas of heat flow, calorimetry, and their importance.

Introduction to Lesson [5 minutes]:

Agenda (write on board):

1. What is heat and how do we quantify it? (write down heat equation q = msdT)

2. Calorimetry as a tool for measuring heat flow
3. Calorimetry as a tool for identifying pure substances
4. Processing experimental calorimetry data to identify unknown pure substances
5. Reflect on how use calorimetry outside of classroom
6. Homework (develop an experiment to identify unknown substances using calorimetry)

Procedure [Time needed, include additional steps if needed]:

Pre-Class Individual Space Activities and Resources:

Steps	**Purpose**	**Estimated Time**	**Learning Objective**
Step 1: Write down the definition of heat, and draw a picture to illustrate heat flow between hot and cold objects	Before discussing calorimetry, a tool to measure heat, we need to know what exactly is heat	5 minutes	**B1**
Step 2: Write down the heat equation, and define each of the variables. In a single heat equation are we permitted to use mass of one object and specific heat of another?	Recognize the heat equation and the relevant variables, and how the variables are related to each other	5 minutes	**B2**
Step 3: Compute the heat released by 100.g of water cooling from 90 degrees Celsius to room temperature (25 degrees Celsius). Use the table of specific heat of common substances (http://www.engineeringtoolbox.com/specific-heat-capacity-d_391.html).	Use the heat equation to calculate heat flow from a substance	15 minutes	**B2**
Step 4: Draw a diagram representing the heat flow occurring in a coffee cup with 100.g of water cooling from 90 degrees Celsius to room temperature (the above system, only this time placed in a coffee cup)	Demonstrate understanding of connection between heat equation and heat flow in real-life	15 minutes	**B1**

Step 5: Imagine a hot piece of iron (100 degrees Celsius) dropped into the room temperature cup from step 4. What do you expect to happen to the temperature of the piece of iron? What do you expect to happen to the temperature of the water?	Establish conceptual understanding of heat flow from hot to cold object and the changes in temperature	5 minutes	**B1**

In-Class Group Space Activities and Resources:

Students form groups of 3-4 people to work through in-class activities.

Steps	**Purpose**	**Estimated Time**	**Learning Objective**
Step 1: In your group, compare your diagrams from the pre-class assignment. Identify the differences in your diagrams, and identify the similarities. Identify the justification for each person's diagrams.	Think critically about the pre-class assignment and find consensus among classmates	10 minutes	**A3**
Step 2: Together, draw a diagram representing the heat flow from a hot piece of copper to 100.g of room temperature water in a coffee cup. Explain what should happen to the final temperature of both the copper and the water.	Critically examine a problem together until consensus is reached.	5 minutes	**A3**
Step 3: Individually evaluate the heat lost by a 1.0g piece of copper cooling from 100. degrees Celsius to 34 degrees Celsius. Calculate the heat gained by 100.g of water rising in temperature from 25 degrees Celsius to 34 degrees Celsius. Compare calculations.	Calculate heat loss and heat gained	10 minutes	**B2**

Step 4: Is the heat lost by copper and heat gained by water in step 3 equivalent? If so, then do the calculations above accurately model the heat exchange between a hot copper metal placed in a room temperature cup of water?	Connect the heat equation to calorimetry	**10 minutes**	**B4 & B5**
Step 5: Suppose you have 1.0g of an unknown piece of metal which is heated to 90 degrees Celsius. The metal is then placed in a coffee cup calorimeter with 100.g of water at 25 degrees Celsius. Compute the specific heat of the unknown metal and compare to the table of specific heats of common substances. What is the identity of the piece of metal?	Perform a calorimetry calculation	**15 minutes**	**A1**

Closure/Evaluation:

Ask the class to answer the following questions on an exit card: How does calorimetry work? How is it used to determine the identity of a substance? What questions do you have about calorimetry?

Analysis:

This lesson uses a combination of methods (group work, pre-class homework, teaching other students) to aid students in learning the importance of calorimetry and how to use it to produce useful information. Furthermore, calorimetry is an everyday relevant technique to identify, for example, the energy content in food which we see on our food labels. Students will thus walk away from this assignment with an understanding of the real-life applicability of chemistry.

Post-Class Individual Space Activities:

Distribute homework assignment: The students should design an experiment for their classmates to identify three unknown substances using coffee cup calorimetry. Use the steps from the pre-class and in-class activities to guide your construction of the labs.

Connections to Future Lesson Plan(s):

Calorimetry provides a basis for understanding thermodynamics, which governs how we understand much of chemistry. Students will be able to connect the flow of heat to future principles covered in this course. For example, we now have a way to think about phase changes as resulting from the flow of heat.