TIME FRAME: to be taught mid-March 2006

LESSON RATIONALE:

This three day lesson plan revolves around the driving question, "What happens when you break a cold/hot pack?" and reinforces the concept of science as inquiry. Inquiry requires students to think, engaging their cognitive abilities to try to pass from the concrete operational stage of thinking to the formal operational stage. Research shows that teachers who spend time helping their students to develop a qualitative understanding of concepts also increases the students' ability to solve quantitative problems. On the other hand, students who are able to solve problems quantitatively do not necessarily have a qualitative understanding.

In this class the students will have previously learned about the kinetic processes and systems and their surroundings. Students will take this previous knowledge to try to reason their way through the heat changes when activating a cold/hot pack. After collecting their thoughts, the students will then in groups experiment with four different substances to see how they react with one another and record their results. The students develop the experiment; they develop the procedure and the data tables to record their observations. The students will finally have to categorize the reactions into groups based on their observations. This allows students to understand concepts qualitatively before being told specifically what endothermic and exothermic reactions are.

This lesson plan follow in suit with the activity model for scientific inquiry in that students experience the scientific method through prediction, investigation of the known, carrying out the study, observing, examining the results, reflecting on their findings and communicating with others. Investigation of the known is done when students access their prior knowledge and present their previous ideas about the system. Students then have to carry out the study by designing the experiment and how data is to be recorded. Observation occurs as students do the experiment and record the results. The students then have to examine their results categorizing them, and then reflecting on how to categorize the reactions. Communication with others is done throughout the lesson and students share their prior knowledge, work together to create and implement the laboratory design and decide what the results mean.

CALIFORNIA CONTENT STANDARD:

Our standard is Chemistry 7b
7. Energy is exchanged or transformed in all chemical reactions and physical changes of matter. As a basis for understanding this concept:

b. Students know chemical processes can either release (exothermic) or absorb (endothermic) thermal energy

LEARNING OBJECTIVES

Given a question on chemical thermodynamics and specific materials, students will create a data table and lab procedure for an experiment, demonstrating knowledge of the scientific method.

Given procedures authored by students, students will complete an investigation of exothermic and endothermic reactions where they collect and analyze data that illustrate these reactions.

Given a background discussion on thermal energy, heat, and lab results; students will write a paragraph demonstrating their understanding of both exothermic and endothermic reactions through relating these terms to the phenomenon of a hot and cold pack.

ASSESSMENT

Assessment Activity	Evaluation Criteria	What is Assessed	Student Feedback
Checking current conceptions about thermal energy changes in a system by posing a question.	Completion of Worksheet and Class Participation	1: Completion of Before/After Worksheet 2: Students participation with partner. 3: Groups participation as a class.	1: Points or stamp on completed worksheet 2&3: Class participation – Teacher monitors groups and guides with directed questions but lets the students work it out.
Ability of students to collaborate in creation of a lab activity where they must analyze and synthesize data	Completeness of lab objective and procedure	Adequate thoroughness of the procedure and data sheets indicating student learning. Can another student perform this procedure as written and does it meet the lab purpose?	The teacher has the students turn in their prediction and datasheets checking for student ideas, required modifications, and material preparations.
Experimentation skills – are the students able to follow their procedures and create their own ideas.	Ability to follow procedure, record data, and evaluate	Whether the students were able to complete the data collection as directed and how well they documented observations.	The teacher reviews the datasheets for completion prior to clean-up. Guided questions such as “what happened here” or “what did you find out” may be necessary.
Concept understanding, vocabulary, and framework – Grouping reactions	Ability to relate observations to scientific vocabulary and concepts	1: Students ability to analyze data by grouping like results. 2: Ability to relate this analysis to the posed question. 3: Understand and relating the scientific language for their experiment.	1: Guidance if there are questionable results. 2: Students provide 3x5 card teacher with their definition of reaction in the hot/cold pack. 3: Students summarize what happened to the heat in the groups of like results Teacher names these grouped reactions for the class understanding of the scientific terms for endothermic and exothermic reactions.

INSTRUCTIONAL STRATEGIES AND TASKS TO SUPPORT LEARNING

Day 1 Time: 53 minutes Period 1: Engage and Connect
8:00 – 8:20 (20 minutes) Warm Up

- An overhead is projected on the screen which instructs to students to sit with their lab partners today and to create a chart on a piece of paper like the following

Before	After

- The driving question of the unit is posted on the overhead as well above the chart: "What happens when you break a cold/hot pack?" and students are asked to include this question in their notes.
- Each lab group is given a hot pack of the type that you snap
- Students are instructed verbally to record observations describing the hot pack as they have received it (without snapping) in "Before" column
- Students then break the hot pack and record observations describing the hot pack now in the "After" column
- A diagram of the hot pack is drawn on the board and the instructor asks a volunteer to draw (using arrows) the direction of heat flow. The instructor asks students where the heat is moving, where heat is coming from, what is the system vs. the surroundings.
- Students are given half sheet (Living By Chemistry Unit 5 Investigation 1 Lesson 3 pg 37) Questions 1-3 related to melting ice cube to complete independently.
- After working for approximately five minutes students are instructed to share their ideas with their lab partners and compare. The lab groups then share with the class as a whole

Purpose: There are several main goals in this warm up. First, the driving question for the three day unit is introduced. Second, students revisit information and vocabulary introduced in the days leading up to this activity (systems/surroundings) and attempt to apply it in a new context. Third, this allows the teacher to assess their current conceptions about the thermal energy changes in this system. Fourth, by assessing prior knowledge of the students they will have a context in which to place the information they will be given. Fifth, the students are given the question hence this is a guided rather than open inquiry activity but in order for it to be inquiry it is important that students are allowed to make predictions and engage in higher level thinking.

Develop and Instruct

8:20 – 8:27 (7 minutes) Review and Introduction to Activity

- Question and Answer between the teacher and students involving questions like the following:

    - What does it mean when something is cold (at the molecular level)?
    - Why do things feel cold?
    - How does something become cold – in terms of molecular motion?
    - Is coldness added to the system or is heat taken away?

  These questions would be modified depending on how much of this material was already correctly explained by their warm up descriptions.
- Introduction to tomorrow's activity: "Tomorrow in lab you will receive four chemicals plus water for your lab. Your job today is in your lab groups to design an experiment to use these chemicals to determine how temperature/heat/cold are involved in chemical reactions. "Do reactions create change in temperatures themselves, If so how?"
- One example is given to help students get started for instance: "If I mix chemical A with water what happens, what if I mix chemical A and B?"
- Things to remind students of:
    - Does it make a difference which order I mix the chemicals in (A with B vs. B with A)?
    - Does it make a difference whether the chemicals are in solution or not?
    - What happens if I mix A with B with C?
    - Will you measure a change in temperature qualitatively or quantitatively?

Purpose: This time is devoted to explaining the question that each student is expected to answer over the next days. Before the project may be introduced the teacher must review the material to check for understanding of previous information. It allows the teacher a time to mention the complexities of the experiment. By having the students create their own procedure the activity falls into the guided area of the inquiry spectrum. Because the students invent their own procedure they take ownership of the project and this will increase curiosity and retention of information. However the teacher is still present as an expert to prompt students' thinking.

8:27- 8:50 (23 minutes) Small Group Work

- Students are instructed that by the end of class they are to turn in a blank data table for their lab tomorrow and a prediction of the ways in which heat energy may be transferred in a chemical reaction.
- Students spend this time in their groups developing their procedure and creating tables to record their data in an organized fashion for the lab.
- The teacher monitors each group's progress and scaffolds those who need additional assistance.

Purpose: The collaborative nature of this activity will encourage constructivist learning. The teacher acts as a coach as the groups develop their individualized plans. Students are engaged in higher levels of thinking as they must analyze and synthesize information in order to create a coherent procedure and assessment criteria.

Assess and Close

8:50 – 8:53 (3 minutes) Clean Up and Collection

- Students turn in their data tables and predictions to the teacher for assessment
- Any reorganization of the classroom occurs before the bell rings

Purpose: Having a few moments before the end of class allows students and the teacher to regroup preventing chaos when the bell rings. The data tables and predictions are collected to allow the teacher to 1. obtain a general sense of how sophisticated students ideas on this topic already are 2. look for modifications to any procedures that much be made 3. prepare materials for the next day for each group. Requiring students to turn something in by the end of class also ensure that students will be on task during the period rather than waiting to do the assignment at home or never doing it.

Day 2 Time: 53 minutes period 1

Engage and Connect

8:00 – 8:07 (7 minutes) Instructions

- The driving question is written on the board or in some place where it is visible to students.
- The teacher reminds the students orally of the driving question. They also give any safety precautions necessary for the day and speak to those groups with whom modifications need to be made. It is likely these modifications will be minor because the teacher will have been monitoring their procedures the previous day.
- The teacher also instructs students as to where they can locate the chemicals and glassware they may need and how much of each chemical is an appropriate amount to use. Students should receive a reminder that they are to be thinking about how heat is moving in each one of their reactions.

Purpose: It is essential that the teacher touch base with students at the start of the day. Many students may need to be reminded what it is they are engaging in and why they are doing it. It is also crucial that safety issues be addressed to prevent injury or accidents.
Develop and Instruct

8:07-8:48 (41 minutes) Experimentation

- Students have access to the following chemicals to complete the assignment: $CaCl_2$, Baking Soda, $Ba(OH)_2$ pellets, NH_4SCN
- These chemicals can be combined safely to create exothermic, endothermic and energetically neutral reactions.
- Students should record any changes in temperature that occur but also other observations as well. For example $CaCl_2$ and Baking Soda when combined in water will produce large amounts of foam.
- The teacher monitors each group for safety concerns and to assist in any questions they may have. The teacher will also be monitoring progress on the assignment.

Purpose: This is the time in which students perform their actual experiments and collect data to be analyzed. The students work in their groups to follow their own procedure which creates ownership of the material. By observing the reactions they create their own ideas about what is possible.

Assess and Close

8:48-8:53 (5 minutes) Clean Up and Closure

- Students wash and return glassware and ensure that they have all the necessary data recorded.
- Students are required to write on a 3 by 5 card the reaction that most resembled the hot pack demo they observed yesterday.
- Students turn in these 3 by 5 cards as they leave the room.

Purpose: This time ensure that the lab is not left in a disordered state. The card is required in order to remind students of how the lab connects to the driving question and to give the teacher another way to check that the experiments occurred as should have and that students were observant of the reactions.

Day 3 Time 53 minutes period 1

Engage and Connect

8:00- 8:15 (15 minutes) Warm Up

- The driving question continues to be on the board
- Two lab groups meet and compare their results to yesterday's laboratory experiment. They look for inconsistencies and negotiate until a consensus is formed on each reaction. They are also to look for differences between their procedure and the other lab groups.

Purpose: This reviews the information they gathered yesterday. By explaining their results to another group they each have a chance to organize the information in their own heads. Comparing procedures reinforces the idea that scientists do not go about their work in exactly the same manner and many methods may be valid. This also gives students a chance to review their own work and locate any errors that may have occurred the previous day.

Develop and Instruct

8:15-8:35 (20 minutes) Group and Label

- Each student is asked to individually create groupings of the reactions from the previous days lab that occurred based upon heat transfer on a piece of paper. (All of the reactions that lost energy would be in the same grouping)
- Students then compare their reaction groupings with their lab partners. As a group they are asked to create a name for each group that describes the characteristic of that group.

For example the labels might be Heat Lost, Heat Gained, No Heat Transfer. In addition they need to draw a sample diagram for each three showing heat transfer.
- Students then write in 1-2 sentences what happened in each group i.e. where did the heat move to and from using the vocabulary of system and surroundings.

Purpose: This set of activities and conversations allows students to create their own set of categories that the teacher can then apply the labels of exothermic and endothermic too. They have constructed the concepts themselves and then the teacher's job is simply to give new scientific vocabulary to these groups. They also have a written explanation for each concept. They know the definitions of the words and what happens in each type of reaction without knowing the words themselves.

8:35-8:45 (10 minutes) Introduction of New Vocabulary

- The teacher asks for each groups' labels to create a whole class list.
- The teacher then introduces the scientific labels for each of these groups: endothermic and exothermic. Some discussion of the Latin roots of these terms may prove helpful to students.

Purpose: The students now how a deep understanding of the concepts and have a conceptual framework in which to place this new vocabulary so that it will remain a part of their knowledge. They now understand both the definition and the terminology.

Assess and Close

8:45-8:53 (8 minutes) Application to New Situation

- Each lab group is given a cold pack. They are asked to create the same table as on day one and record observations before and after the cold pack is broken.
- Their homework assignment is to **Draw a diagram showing heat transfer and label the system and surroundings in the cold pack reaction. Write a paragraph explaining the phenomenon of the cold pack using the terminology of exothermic, endothermic, system and surroundings. Be sure to include how you know whether it is an exothermic or endothermic reaction (give evidence). Compare what occurred in the hot pack demonstration with the cold pack.**

Purpose: The closure activity is designed to provide students with an opportunity to practice using their new vocabulary with a similar but new situation. This will allow the instructor to assess how comfortable students are with the new terminology and whether they can analyze a new system with the information they have learned.

The following day we will discuss students' responses, they will share with the class and then have a discussion around the questions "If you believe that heat is entering the system, why does the temperature of the cold pack go down? What is the energy being used for if it isn't being used to raise the temperature?"

Materials we will bring to Spring/Summer meeting

- Videotape of at least one (most likely all three/maybe even four) days of teaching
- Student work – at least two, including 3 x 5 cards, data tables/procedures, before and after charts, reaction groupings, final explanations
- Katie's reflections
- Notes/reflections from Holly either from video of me teaching, or from her watching me teach in Cal.

Scaffolding Steps that must come before this lesson in order to prevent against disaster:

- Students must have some knowledge of matrixes/ spreadsheets – I can guarantee they will have lots of experience with Excel
- Know various aspects of scientific method – understand how/why one variable must be held constant
- Know how to record qualitative and quantitative observations – experience reading thermometers, comparing data and describing reactions
- Preliminary knowledge of the kind of information included in a procedure and possibly experience helping to create a procedure (maybe a whole class activity previous to this lesson)
- Practice writing in science class about scientific phenomenon, and explaining observations and thought processes

Appendix 1: Example of Data Collection Tables

Table 1. Results of How Baking Soda Reacts with other Substances.

	Baking Soda	Result
Water added		
Second substance Added		
Third substance Added		
Fourth substance Added		

Table 2. Results of How $Ba(OH)_2$ (pellets) Reacts with other Substances.

	$Ba(OH)_2$ (pellets)	Result
Water added		
Second substance Added		
Third substance Added		
Fourth substance Added		

Table 3. Results of How $CaCl_2$ Reacts with other Substances.

	$CaCl_2$	Result
Water added		
Second substance Added		
Third substance Added		
Fourth substance Added		

Table 4. Results of How NH_4SCN Reacts with other Substances.

	NH_4SCN	Result
Water added		
Second substance Added		
Third substance Added		
Fourth substance Added		