EXAMINING MEDICAL HOT AND COLD PACKS USING COFFEE-CUP CALORIMETRY (SCH4U)

ANTIK DEY (/USERS/ANTIK-DEY)

Course: Chemistry, Grade 12, University preparation (SCH 4U)

Strand/Unit: Energy Changes and Rates of Reaction

Overview: Physical changes that involve liquids and aqueous solutions can be studied using a polystyrene calorimeter like the one shown in Figure 1. Such materials can be applied to practical thermochemical systems. For example, when athletes are injured, they may immediately hold an “instant cold pack” against the injury; and over time, the athlete may apply “instant hot pack” to help recover. The medical hot/cold pack operates on the principle that certain salts dissolve endothermically in water, while others dissolve exothermically. The amount of heat per unit mass involved in the dissolving of a compound is a characteristic property of that substance. It is called the enthalpy of solution. The purpose of this experiment is to use calorimetry to determine the enthalpy of solution of an unknown salt, and then to use that value to identify the salt in a medical hot/cold pack, from a list of possible candidates (see table 1, which contains the theoretical values).

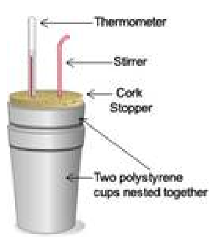

Figure 1. A simple laboratory calorimeter consists of an insulated container made of two nested polystyrene cups, a measured quantity of water, and a thermometer. The chemical system is placed in or dissolved in the water of the calorimeter. Energy transfers between the chemical system and the surrounding water are monitored by measuring changes in the temperature of the water.

Inquiry Focus:

- How can calorimetry be used to determine the identity of an unknown salt?
- What does the value of enthalpy change indicate about heat transfer?
- How could this knowledge of heat transfer extend our understanding of medical hot/cold packs?

Timeline:

- 3.5 class periods (assume 70 minutes per class).
- Time required depends on students’ background knowledge, skill set, and level of interest

Big Ideas:

- To relate science to technology, society and the environment.
- Develop the skills, strategies, and habits of mind required for scientific inquiry.

Overall Expectations:

- A1. Demonstrate scientific investigation skills (related to both inquiry and research in the four areas of skills (initiating and planning, performing and recording, analysing and interpreting, and communicating).
- D2. Investigate and analyze energy changes and rates of reaction in physical and chemical processes, and solve related problems.

Specific Expectations:

- A1.2 select appropriate instruments (e.g., glassware, calorimeter, thermometer) and materials (e.g., chemical compounds and solutions), and identify appropriate methods and techniques, and procedures for each inquiry.
- A1.4 apply knowledge and understanding of safe laboratory practices and procedures…interpret WHMIS symbols… handling and storing laboratory equipment…using appropriate personal protection.
- A1.5 conduct inquiries, controlling relevant variables, adapting or extending procedures as required, and using appropriate materials and equipment safely, accurately, and effectively, to collect observations and data.
- A1.6 compile accurate data from laboratory…and organize and record the data, using appropriate formats, including tables, flow charts, graphs, and/or diagrams.
- A1.11 communicate ideas, plans, procedure, results and conclusions…using appropriate language and a variety of formats.
- A1.12 use appropriate numeric, symbolic, and graphic modes of representation, and appropriate units of measurements (e.g., SI units, imperial units).
- D2.1. use appropriate terminology related to energy changes and rates of reaction, including, but not limited to: enthalpy, activation energy, endothermic, exothermic, potential energy, and specific head capacity [C].
- D2.3. solve problems involving analysis of heat transfer in a chemical reaction, using equation $Q = mc\Delta T$ (in J/mol) [AI, C].
- D2.4. plan and conduct an inquiry to calculate, using a calorimeter, the heat of reaction of a substance, compare the actual heat of reaction to the theoretical value, and suggest sources of experimental error [IP, PR, AI, C].
- D3.3 explain how mass, heat capacity, and change in temperature of a substance determine the amount of heat gained or lost by the substance.

(Ontario Ministry of Education, 2008)

Key Concepts:

- Enthalpy changes; calorimetry; endothermic and exothermic processes.

Prior Skill Sets:

- How to set up the coffee-cup calorimeter apparatus.
- The proper use of the following instruments:
  - Scoopula to obtain a certain mass of the salt.
  - Using the analytical balance accurately (tare first, then add salt).
  - Recording mass to two decimal places.
  - Using the thermometer to measure changes in temperature to one decimal place.
  - Effectively swirling the calorimeter to ensure effective mixing.

Prior Knowledge:

- Differentiate between system and surrounding.
- Relationship between heat and temperature.
- Calculating enthalpy changes given specific heat capacity, mass, change in temperature.
- Determining if a process is exothermic or endothermic from the ΔH value.
- How a calorimeter works.
- Determining ΔH using calorimetry by considering limiting reactants.
- Identify various laboratory instruments including, analytical balances, beakers, thermometers, et cetera.

Materials and Equipment:

- Lab coats, goggles
- Analytical balances (can be shared)
- 6 g of an unknown salt (from the list of Table 1)
- Stirring rod
- Deionized water
- Thermometers, cork stoppers (an inverted third cup could also be used)
- 2 Styrofoam cups (per group)
- 100 mL graduated cylinder (per group)

Table 1. Enthalpies of solution for compounds in a Medical Hot/Cold Pack

Salt	Enthalpy of Solution (kJ/g)
Ammonium chloride, NH_4Cl	0.277
Potassium nitrate, KNO_3	0.345
Ammonium nitrate, NH_4NO_3	0.321
Sodium acetate trihydrate, $NaC_2H_3O_2 \cdot 3H_2O$	0.144
Potassium chloride, KCl	0.231
Calcium chloride, $CaCl_2$	-0.746
Sodium acetate anhydrous, $NaCH_3COO$	-0.211
Potassium hydroxide, KOH	-0.998
Sodium hydroxide, NaOH	-1.108

Calculated from data provided by Martinez (1995).

Safety:

1. Students should adhere to the following laboratory practices which include, but not limited to:
   - Avoid any horseplay with and practical jokes on other students using chemicals or laboratory equipment.
   - Coats, bags, cell phones, and other personal items should not be allowed in the laboratory space.
   - Wear proper safety equipment as instructed by the teacher (goggles, lab coat, closed-toe and closed heel shoes).
   - Remove loose clothing and jewelry, and tie back long hair.

- No eating, drinking, or chewing gum in the laboratory.
- No ingesting or smelling of chemical substances.
- Never handle solids with the fingers. Instead, use a scoopula or its equivalent.
- Never return excess solids to its container, as it may result in cross-contamination.
- Know where the emergency exits are located and where to go if the classroom or building is evacuated. (Science Teachers' Association of Ontario, 2002)

2. In the event of a broken mercury thermometer:
    - Clear the area of the spill and provide maximum ventilation before cleaning up.
    - Placing plastic bags over shoes may avoid extending the mercury contamination beyond its original area.
    - Mercury cleanup kits are effective for small or modest spills. For larger spills, possibly consider a mercury vacuum cleaner. Mercury must be disposed of as a hazardous waste. (Science Safety Handbook for California Public Schools, 2014)
3. Following is the precautions of the various salts that will be used:
    - NH_4Cl, ammonium chloride, can cause skin and eye irritation. Keep away from acids, bases, and lead salts.
    - NH_4NO_3, ammonium nitrate, is highly reactive and explosive if heated. Can explode at lower temperature if contaminated. Keep away from oxidizing agents, reducing agents, metals, and organic materials.
    - $CaCl_2$, calcium chloride, is an irritant, but low hazard.
    - KCl, potassium chloride, low hazard.
    - Potassium nitrate, KNO_3, an oxidizing agent. Can form explosive mixtures with combustible material. Keep away from reducing agents and organic material.
    - NaOH, sodium hydroxide, is highly corrosive. Keep away from acids, and metals.
    - Dispose all salt solutions in the disposal beaker provided by the teacher.
    - Sweep up with a brush into a dustpan, taking care to avoid raising dust. Wipe the area with a damp disposable cloth.

(Science Teachers' Association of Ontario, 2002; High School Science Safety Resource Manual for Newfoundland and Labrador Schools, n.d.)

Instructional Planning and Delivery:

Day	Activity

Prior to Day 1 (at the start of the semester)	**(1) <u>Note-taking strategies</u>:** **30 minutes* • At the beginning of the course, students are introduced to three note-taking strategies: Cornell; Web; and Chart. • The Cornell method divides the paper vertically in two, allowing for notes on the right hand side, and key-words on the left. This is an effective tool for summary and review. • The second method, the Web, is a concept map that allows students to draw relationships between important concepts. This is an effective way to learn causal relationships. • Lastly, the Chart method requires students to draw a table with various column headings. This is an effective tool to remember dates and events. • Students in my class are not only introduced to these methods, but are encouraged to master them. Before coming to class, each student is invited to preview the material by making notes using the three strategies. From this, students practice reading science in their textbook or in an article, and determine the important concepts and relationships, independently, prior to entering the lesson. • These would be considered formative assessments. (Worksheet #2, used in coordination with the PowerPoint slides “Note taking strategies”) *(1.1) Implications:* • By previewing the material, students are encouraged to improve independent learning skills, which are critical for inquiry-based learning activities. • Students’ also develop their higher-order-thinking skills (HOTS) from critically examining the most appropriate method of representation of each topic. **(2) <u>Common lab equipment handout</u>:** • Students are provided with a handout that visually represents some of the common laboratory equipment. • Throughout the unit when we are learning about systems, surroundings, et cetera, it is beneficial to incorporate the use of various instruments in your discussion. • For example, using an open beaker to visualize an open system, while an Erlenmeyer flask with a rubber stopper could be a visual aid for a closed system. (Worksheet #1) *(2.1) Implications:* • It is a good away to help visualize and learn to identify various laboratory instruments that will be used in the inquiry-based activity.
1	Leading up to this day, in preparation for the inquiry-based activity, students were assigned one of their note-taking assignments to be due

(70 min) on this day.

(1) Note-taking assignment: **2 minutes for collection**

Students will be encouraged to preview the following topics from their textbook:

- Calorimetry
- Using a Calorimeter
- Using a Calorimeter to Determine the Enthalpy of a Reaction

And, make notes using the abovementioned methods. Students will need to demonstrate the effective use of each method.

(1.1) Teacher Tip:

When assessing their notes, watch for the following alternative conceptions:

- In exothermic and endothermic processes, heat is only released and absorbed, respectively. However, it is important to clarify that NET heat is released or absorbed, which is indicated by the positive/negative ΔH value.
- Teachers may also need to clarify that in a calorimeter the change in temperature is of the surrounding, not the system. Therefore, an increase in temperature indicates the system is undergoing an exothermic process. Similarly, a decrease in temperature indicates the system is undergoing an endothermic reaction.
- These possible alternative conceptions should be addressed at a future lesson.

Once the note-taking assignment has been collected at the beginning of class, we begin our discussion around calorimetry.

(2) Building on prior knowledge: **15 minutes**

- So far students have learned how to calculate the amount of heat, q, absorbed or released in both chemical and physical processes. Let's look closely at $q = n\ \Delta H$. Students can calculate q by knowing the values of n and ΔH. From grade 11, students know that, n, represent the amount of mol of a substance, and can be calculated from the various formulae learned in Stoichiometry.
- And as for enthalpy changes, the values of ΔH_{form}, ΔH_{comb}, ΔH_{cond}, ΔH_{vap}, ΔH_{soln}, et cetera were provided in the textbook.

(2.1) Guiding Question: Where did these ΔH values come from? In other words, how did one determine the values presented in tables?

- Technology was required, and hence today's topic is on the technology of heat measurement.

(2.2) Teacher Tip:

- Encourage students to see the ultimate goal of this chapter, which revolves around determining enthalpy changes in order to calculate how much energy has been either gained or lost in the form of heat.

(2.3) Implications:

- By tapping into their prior knowledge, students are able to make deeper connections in their memory, which in turn, facilitates HOTS.

(3) <u>Link to real world scenarios</u>: **10 minutes**

(3.1) Guiding Question: In the real world, why is it necessary to determine the amount of energy absorbed or released?

- Discussion can be around energy in food (calories) and nutrition. For example, comparing the nutrition table of a juice box with that of a Big Mac hamburger. This engages biology students.
- Discussion could also be around the design and use of dynamite bomb in the field of construction, and the importance of knowing how much energy will be released. This engages physics students.

(3.2)Teacher tip:

- Prepare some props, such as an empty juice box, which could be passed around the class and students can volunteer to read the calorie information.
- See PowerPoint titled “the technology of heat measurement.”

(3.3) Implications:

- By relating textbook knowledge with the real world, students are able to personalize with the content, which in turn, promotes HOTS and long-term memory (enduring knowledge).
- In addition, by drawing concepts from other sciences, namely biology and physics, students will better appreciate the interconnectedness of the sciences.

(4) <u>Introduce coffee-cup calorimetry</u>: **5 minutes**

- Using PowerPoint slides students are taking notes and participating in discussion, as the teacher draws on prior knowledge from chemistry and other sciences, in a Socratic manner.

(4.1) Teacher tip:

- Pay close attention to vocabulary, namely calorimeter. Chunking the word into “calorie” and “meter” will help students store the meaning in their long-term memory (enduring knowledge).
- “Calorie” means energy, and “meter” means, measurement. Therefore, this instrument measures energy.

(5) <u>Recall Law of Conservation of Energy</u>: **10 minutes**

- From their understanding of the principles of calorimetry and the law of conservation of energy, students will be encouraged to appreciate: $q_{reaction} = - q_{water}$.
- From which students will be able to derive the following formula for enthalpy change:

$$\Delta H\, rxn = \frac{-(mc\Delta T)}{n\,(rxn)}$$

(5.1) Teacher tips:

- ‘Rxn’ stands for Reaction. The “n” is the amount of mole of the limiting reactant.
- Discuss the three assumptions necessary to be able to use this formula:

i. Isolated system
ii. No heat exchange between system and the calorimeter
iii. Reactants have the same properties as water (density and specific heat capacity)

(6) <u>Analyze a sample calorimetry problem</u>: **15 minutes**

- Go through a calorimetry word problem with the class
- See PowerPoint titled “the technology of heat measurement”

(6.1) Teacher tip:

- Notice that both reactants are in aqueous state, which means diluted with water, and therefore, both of their masses will need to be included in $q_{water} = m\,c\,\Delta T$. Another clue is the fact that the initial temperature of BOTH solutions was measured, and since we assume that the specific heat capacity will be the same as water, we can easily calculate q_{water}. Since $q_{rxn} = -q_{water}$, we can determine the enthalpy change of the reaction from the abovementioned formula. (*Hint*, $q_{rxn} = n\,\Delta H$.)

(7) <u>Video on Calorimetry</u>: **5 minutes**

- Encourage students to watch a video (with engaging graphics) on calorimetry and make any additional notes to their lesson from today. This video helps reinforce key concepts addressed in today's lesson: https://www.youtube.com/watch?v=EAgbknIDKNo (https://www.youtube.com/watch?v=EAgbknIDKNo)

(7.1) Implications:

- The engaging graphics of the video brings the inquiry-based activity to life. Students will gain insight into the appropriate apparatus design and laboratory technique.

(8) Homework: **2 minutes to deliver the instructions**

- Students are given a handout with two Thinking & Inquiry type problems. Their task will be to be complete the both questions, and submit it the next day for peer-evaluation. (Worksheet # 3)
- Students can use the remainder of class time (~5 minutes) to get started on the problem set.

(8.1) Curriculum outcomes:

- D2.3

2

(70 min)

(1) Peer-evaluation of homework problem set: **20 minutes**

- Students will submit their practice problem worksheet to the teacher.
- The teacher will then randomly choose evaluators for each student. The evaluators will check for mathematical conventions, final answer, and overall format.

(1.1) Implications:

- This activity is assessment *as* learning, where the numerical feedback is not recorded. There is however a spot for written feedback, which will encourage students reflect on their own learning as they thoughtfully examine the mathematical solutions presented by their peers. This is a metacognitive approach.

(2) Taking up homework as a class: **10 minutes**

- Teacher will go through the solution with the class, step by step, with the help of student volunteers. Students will guide the teacher in solving the problems. Teacher should simply ask questions like: "what is our first step?" and "what is our next step?"

(2.1) Teacher tip:

- The lesson highlighted the importance of determining the limiting reactant. However, the two questions in the problem set gave clues as to which reactant is limiting. In question 1, the clue is in the phrase, “sufficiently concentrated NaOH,” which would indicate that the other reactant, HCl, is the limiting reactant. In question 2, the clue is in the phrase “calculate the enthalpy change…of Mg…” This indicates that the limiting reactant is Mg.

(2.2) Source of Alternative Conception:

- Students may add the mass of both reactants (as shown in the classroom example) when calculating $q_{water} = m c \Delta T$. In question 1, it would be correct, as both reactants are solutions (diluted with water), and the initial temperature of both reactants were recorded. In question 2, however, the mass of both reactants cannot be added when calculating q_{water} for two reasons. First, Mg is not in aqueous form, and second, we do not know the initial temperature of the solid metal.

(3) <u>Preparation for the inquiry activity next class</u>: **25 minutes**

- Students will read the lab handout for a mini pre-lab quiz to take place in the last 15 minutes of the class.
- Students should be familiar with the objective of the lab, materials, and make a flow chart of the procedure in their own words.
- For the flow chart, students should be encouraged to use visuals where ever possible. (See Worksheet # 4 for the inquiry activity handout)

(3.1) Implications:

- Effective preparedness will reduce the risk of safety hazards, while improving time management during the inquiry activity.
- The flow chart will make it easier for students to follow the structured inquiry activity. Teachers should walk around to check the completion of the flow charts.

(4) <u>Administer the Pre-lab quiz</u>: **15 minutes**

- Includes only Knowledge & Understanding style questions regarding basic content, lab procedure, and equipment.
- This is an assessment *of* learning, with a total of 10 marks. Teacher will gain insight as to the level of preparedness of students.
- This quiz will guide the teacher to re-inforce important ideas for the next class (the day of the activity). (See Worksheet # 5)

(4.1) Curriculum Outcomes:

- A1.2; A1.12; D2.1

3

(70 min)

(1) <u>Reinforcement of the inquiry activity</u>: **15 minutes**

- Teacher will reinforce important concepts, some of which were guided by the results from the pre-lab quiz. This can be done by the choral-response method.
- In this method, the teacher will orally reinforce ideas in the form of questions, and students will verbally respond in unison. This strategy is formative in nature, as the assessment is used *for* learning.
- The objective, materials, safety of the materials, and procedure should all be highlighted. In addition, the write-up section of the lab should also be discussed, so students go into the activity knowing the ultimate goal and the evaluation expectations.

(1.1) Teacher tip:

- Grouping strategy is always important, and teachers should be aware of the various approaches.
- Teachers can allow the students to choose, or teachers can make the groups based on skill and achievement, or even mix students up, in an attempt to promote cooperative learning strategy.
- In any situation, 3 students per group would be ideal.

(1.2) Implications:

- Choral response method mentioned above is an effective tool to gauge students' level of preparedness and enthusiasm. It allows students to provide feedback to the teacher, while the teacher, simultaneously, is able to return feedback to the students in the form of assessment *for* learning.

(2) <u>Teacher acts as a facilitator</u>: **45 minutes**

- As the students embark on the activity outlined in Worksheet # 4, teachers should monitor actively, paying close attention to students' safe laboratory practices, distribution of labour and troubleshooting/problem solving skills.
- Teacher acts as a facilitator during this activity, guiding students to arrive at the answer/solution on their own.

(2.1) Implications:

- This structured-inquiry activity is an effective alternative to rote learning, as it actively engages students' in science and invites students to develop HOTS (Hmelo-Silver et al., 2007; Marshall et al., 2009, both as cited in Avsec and Kocijancie, 2015).

- This activity taps into the affective domain of Bloom's taxonomy. By asking students to determine the identity of the unknown salt, students are encouraged by the challenge and the sense of accomplishment (Bloom, et al., 1971; Weigel and Bonica, 2014).
- Students are also encouraged to develop language skills through this inquiry activity. In the discussion section, students are asked to thoughtfully consider sources of error, for which they need to describe and prove how it will impact their result, while also providing improvements for the future (Harlen, 2013).
- Altogether, there are 4 marks awarded for Communication (overall use of language and mathematical conventions); 14 marks for Application (for describing the error and improvements); and 12 marks for Thinking & Inquiry (for providing the proofs of each error, and ΔH calculations and analyses).

(2.2) Teacher tip:

Monitor safe laboratory practices:

i. Students should wear safety goggles, lab coat at all times. Ensure that the analytical balance is clear from any wetness.
ii. Ensure that the students carefully scooping out the salts out of the containers, and not making spills.
iii. Ensure that the container of the salt is closed when not in use, so as to avoid oxidation.
iv. Ensure that any extra salt scooped out is not returned to the original container.
v. Ensure that the scoopula designated for the particular unknown salt is not misplaced.

Ensure equal distribution of labour:

i. Ensure all group members are on task and not playing on any electronic device. Ensure that each student has a role: data recording, obtaining mass of salt and water, trouble-shooting, et cetera.

Troubleshooting:

i. Thermometer readings
ii. Analytical balance readings

(2.3) Curriculum Outcomes:

- A1.2; A1.4; A1.5; A1.6; A1.11; A1.12; D2.1; D2.3; D2.4; D3.3

(3) Clean up: **10 minutes**

- Ensure lab benches have been clean and dried, so there are no remnants of salt particles.
- Solutions have been appropriately placed in their designated disposal beaker.

- Coffee-cup calorimeter should be rinsed and placed upside down on the lab bench, with the lid removed.
- Rinse off the thermometer and graduated cylinders as well.

4

(70 min)

(1) Demonstration of student learning: **2 minutes for collection**

- Students will submit their laboratory write-up individually. This is an assessment *of* learning that evaluates students' achievement in following categories: Thinking & Inquiry; Communication; and Application.

(**2) Administer the Post-lab quiz:** **15 minutes**

- This is to ensure that students adhered to the academic honesty policies of their school, and did not simply copy the lab write-up from a peer.
- The questions are related to calculating enthalpy changes given sample data, and source of error analysis (the concepts from their formal lab write-up).
- This is an assessment *of* learning that evaluates students' achievement in the following categories: Knowledge & Understanding and Thinking & Inquiry. (Worksheet # 6)

(2.1) Curriculum Outcomes:

- A1.12; D2.1; D2.3; D3.3

(3) Continue on to the next topic

(SEE SECTION BELOW)

Accommodations:

1. Technology: Medical "talking" thermometers that read out results can be an effective alternative for students with a visual impairment or dyslexia.
2. Print: Large print books (or documents) should be incorporated to accommodate students with a visual impairment. In addition, trade books would appeal to ESL students, and to those who are linguistically and mathematically challenged, since these books are written for a scientific audience without the scientific vocabulary found in textbooks.
3. Community: It is strongly recommended that teachers collaborate with special education or resource teachers in the school, who have experience working with students that have an individualized education plan (IEP).

Student Support Resources:

- Common Lab equipment (Worksheet #1)
- Note taking methods (Worksheet #2)
- Practice problems (Worksheet #3)
- Laboratory handout (Worksheet #4)
- Pre-lab quiz (Worksheet #5)
- Post-lab quiz (Worksheet #6)
- The technology of heat measurement (PowerPoint slides)
- Note-taking strategies (PowerPoint slides)
- YouTube video on calorimetry (see link above)

Related Background Resources/Links:

Avsec, S., Kocijancic, S. (2016). A Path Model of Effective Technology-Intensive Inquiry-Based Learning. *Educational Technology & Society*, 19 (1), 308-320.

Bloom B, Krathwohl D, Masia B, eds. (1971). Taxonomy of Educational Objectives: The Classification of Educational Goals-Handbook II-Affective Domain. *New York, NY: David McKay Company, Inc*.

California Department of Education. (2014). *Science safety handbook for California public schools*. Retrieved from: https://www.cde.ca.gov/pd/ca/sc/documents/scisafebook2014.pdf

Harlen, Wynne. (2013). Inquiry-based learning in science and mathematics. *Review of Science, Mathematics and ICT Education*, 7 (2), 9-33.

High School Science Safety Resource Manual for Newfoundland and Labrador Schools. Retrieved from: https://www.ed.gov.nl.ca/edu/k12/curriculum/documents/science/LabSafetyGuidelines.PDF

Martinez, Isidoro. (1995). Heat of Solution Data for Aqueous Solutions. Retrieved from: http://webserver.dmt.upm.es/~isidoro/dat1/Heat%20of%20solution%20data.pdf

Mccord, P. (2011). *Calorimetry*. Retrieved from: https://www.youtube.com/watch?v=EAgbknIDKNo

Mustoe, F., Jansen, M., Webb, M., Doram, T., Hayhoe, C., Gaylor, J., Ghazariansteja, A. (2004). Chemistry. *McGraw-Hill Ryerson*, 661-667.

Ontario Ministry of Education. (2008). *The Ontario curriculum grades 11 and 12: Science.* Retrieved from: http://www.edu.gov.on.ca/eng/curriculum/secondary/2009science11_12.pdf (http://www.edu.gov.on.ca/eng/curriculum/secondary/2009science11_12.pdf).

Science Teachers' Association of Ontario. (2002). *Stay Safe: A health and safety reference for secondary school science*. Ontario: Author.

Scientific Laboratory Materials. (2016). Retrieved from: https://www.wiatrade.com/scientific-laboratory-materials (https://www.wiatrade.com/scientific-laboratory-materials)

Weigel, F., Bonica, M. (2014). An Active Approach to Bloom's Taxonomy: 2 Games, 2 Classrooms, and 2 Methods. *The United States Army Medical Department Journal*. Retreived from: http://www.cs.amedd.army.mil/amedd_journal.aspx

Assessment Opportunities:

Formative		Summative
Assessment for	*Assessment as*	*Assessment of*
1. Note take assignment 2. Practice problem homework 3. Choral responses 4. Observe the completion of students' flow charts prior to the lab activity.	1. Peer-evaluation of practice problem homework	1. Pre-lab quiz 2. Laboratory write-up 3. Post-lab quiz

Future Opportunities/Extensions:

Physical Therapy

- Investigate how much energy can either be absorbed or released by the medical hot/cold pack for it to be effective to student-athletes. Work backwards to determine the type of salt, and the quantity of both salt and water required. Students should state a hypothesis regarding the effectiveness of hot/cold packs by manipulating the mass of salt used, while keeping the mass of water constant. Students should also determine the materials that will be required to build a medical pack. Using a guided inquiry approach, students could be encouraged to conduct a series of tests on student-athletes at their schools, determining the best treatment for athletes. Their results could be presented at their school science fair or at a business exposition.

Nutritional Science

- From coffee-cup to bomb calorimetry will engage students in determining how much energy (calories) present in various foods. Another example of guided inquiry, where students will have to design a bomb calorimeter, which will necessitate greater attention to safety. Students can, for example, compare the calorie contents of peanuts with candy. This will also require the construction of a hypothesis, planning and execution of an experimental design, which will be followed by analysis and conclusions. Student findings could be displayed at the school's science fair, in an attempt to raise awareness of diet and healthy active living.

Food Science

- Instant food warmer heat pack can be used to prepare myriad of food from coffee to instant noodles. Students could develop their own heat packs that will warm food, without fire and electricity. Portability would be a huge selling point. Using a guided inquiry approach, food warmer heat pack's effectiveness could be tested on various foods and the results could then be showcased at the school's science fair or at a business exposition. See link: https://www.alibaba.com/product-detail/Top-Factory-Disposable-Pocket-Instant Food_60733706891.html?spm=a2700.7724857.normalList.13.124f39d5XpiAPN (https://www.alibaba.com/product-detail/Top-Factory-Disposable-Pocket-Instant%20Food_60733706891.html?spm=a2700.7724857.normalList.13.124f39d5XpiAPN)

(mailto
subject
out
this

(https://
https://
catalyst/examining-
medical-
hot-
and-
cold-
packs-
using-
coffee-
cup-
calorimetry-
sch4u)

WATCH THE VIDEO

02:19 min

(//www.youtube.com/embed/2dMP3m4XugY?width=800&height=450&iframe=true)

RESOURCES

- teaching guide sch 4u medical hot and cold packs antik dey.docx (https://connex.stao.ca/sites/default/files/teaching_guide_sch_4u_medical_hot_and_cold_packs_antik_dey.docx)
- worksheet 1 common lab equipment.docx (https://connex.stao.ca/sites/default/files/worksheet_1_common_lab_equipment.docx)
- worksheet 2 note taking methods.docx (https://connex.stao.ca/sites/default/files/worksheet_2_note_taking_methods.docx)
- worksheet 3 practice problems.docx (https://connex.stao.ca/sites/default/files/worksheet_3_practice_problems.docx)
- worksheet 4 lab handout.docx (https://connex.stao.ca/sites/default/files/worksheet_4_lab_handout.docx)
- worksheet 5 pre lab quiz.docx (https://connex.stao.ca/sites/default/files/worksheet_5_pre_lab_quiz.docx)
- worksheet 6 post lab quiz.docx (https://connex.stao.ca/sites/default/files/worksheet_6_post_lab_quiz.docx)
- note taking strategies.pdf (https://connex.stao.ca/sites/default/files/note_taking_strategies.pdf)
- the technology of heat measurement.pdf (https://connex.stao.ca/sites/default/files/the_technology_of_heat_measurement.pdf)

ELEMENT

- Inquiry (/expert-elements/inquiry)

(/classroom-catalysts) RETURN TO CATALYSTS (/classroom-catalysts)