# Can you design a hot or cold pack?

| **Grade Level:** | **Total Time Required:** |
|---|---|
| 6 | Three 30 minute class sessions OR<br>Two 45 minute class sessions |

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**Lesson Objectives:**

*Students will be able to:*

1. Identify the reactants and products of a chemical reaction.
2. Design and carry out a fair test investigation.
3. Collect, organize, and interpret data from their fair test investigation.
4. Use data or evidence from the fair test investigation to inform the design of a hot/cold pack.

**Indiana Standards:**

**6-8.E.1** Identify the criteria and constraints of a design to ensure a successful solution, taking into account relevant scientific principles and potential impacts on people and the natural environment that may limit possible solutions

**Next Generation Science Standards:**

**S-ETS1-1** Define the criteria and constraints of a design problem with sufficient precision to ensure a successful solution, taking into account relevant scientific principles and potential impacts on people and the natural environment that may limit possible solutions.

**MS-ETS1-2** Evaluate competing design solutions using a systematic process to determine how well they meet the criteria and constraints of the problem.

**MS-ETS1-3** Analyze data from tests to determine similarities and differences among several design solutions to identify the best characteristics of each that can be combined into a new solution to better meet the criteria for success.

**MS-ET1-4** Develop a model to generate data for iterative testing and modification of a proposed object, tool, or process such that an optimal design can be achieved.

## Concepts and Vocabulary

| *Term* | *Defined by a scientist or engineer* | *Defined by a student* |
|---|---|---|
| *Reactant* | A substance that takes part in and undergoes change during a reaction. | Something you add to a reaction |
| *Product* | A substance produced during a chemical reaction. | Something that comes out of a reaction |
| *Chemical reaction* | A process that involves rearrangement of the molecular or ionic structure of a substance, as opposed to a change in physical form or a nuclear reaction. | Mixing chemicals together to cause an explosion |
| *Endothermic* | a chemical reaction accompanied by the absorption of heat. | |
| *Exothermic* | A chemical reaction accompanied by the evolution or production of heat. | |
| *Prototype* | A first or preliminary model of something. | |

## Equipment, Materials, and Tools

*Inquiry Activity:*

| ***Materials*** | | |
|---|---|---|
| 25g Sodium bicarbonate ($NaHCO_3$) [Baking soda] | 25g Sodium chloride (NaCl) [table salt] | Container of water |
| 25g Ammonium nitrate (NH4NO3) | 25g Sodium bicarbonate ($NaHCO_3$) [Baking soda] | Paper towels for spills |
| 25g Anhydrous calcium chloride ($CaCl_2$) | Samples of hot and cold packs from the local pharmacy or supermarket (3 or 4) | Container of water |

| ***Tools*** | | |
|---|---|---|
| A safe container to dump solutions into and seal (waste container) | Safety goggles | Thermometers (one per lab team) |
| 250ml Beakers (4 per lab team) or Plastic cups | Stirring rods (4 per lab team) or popsicle sticks | *Optional: PASCO software, temperature sensor, and USB link* |

*Design Challenge:*

| ***Materials*** | | |
|---|---|---|
| Plastic vials or crushable plastic tubes or pouches* | Scrap pieces of fabric (cotton, felt, or other) | Ziploc © bags (quart size and snack size) |
| Glad Press 'n Seal wrap © | Duct tape | Velcro tape |

| ***Tools*** | | |
|---|---|---|
| Thermometers (one per lab team) | | |

* Plastic vials or crushable plastic tubes or pouches can be found at a local pharmacy.

## Science Content - Basics

The following information is from Mr. Thackwray's Science Unit titled "Hot Pack / Cold Pack" from Howard Debeck Elementary School retrieved November 2010, from http://nobel.scas.bcit.ca/debeck_pt/science/hotColdPack/pack_p1.htm.

Chemicals can store energy and release it in the form of heat. A chemical reaction that releases heat is called an *exothermic reaction*. But chemical reactions can also absorb heat from the environment and get cold. These reactions are called *endothermic reactions*. When chemicals are dissolved in water, sometimes heat is released, and sometimes heat is absorbed.

Hot/cold packs are used by athletes to minimize swelling of injuries such as muscle and joint sprains. They are constructed of a large pouch containing a dry chemical plus an inner pouch of water. The hot/cold pack is activated by breaking the seal on the pouch of water and shaking the pack vigorously. This action mixes the water with the chemical starting the exothermic or endothermic reaction.

If the dissolving of the chemical in water is an endothermic process and absorbs heat energy, it is a good candidate for making a cold pack because this process will lower the temperature of the content of the pack. If the dissolving of the chemical in water is an exothermic process and releases heat energy, it is a good candidate for making a hot pack because this process will raise the temperature of the content of the pack.

# Synopsis of Engineering Design Activity

Synopsis of the Design Activity:

| | |
|---|---|
| Problem: | Current hot/cold packs are too large and require an adult to apply it to the child. |
| Goal: | Design a hot/cold pack for a child that they can apply and keep on the injury without adult supervision. |
| Who is the client: | Happy Family Products |
| End-User: | Children |
| What is the design: | Design a hot/cold pack for children. |
| Criteria: | 1. Protect the skin from direct contact with hot/cold pack.<br>2. Keep hot/cold pack in place on the injury. |
| Constraints: | 1. Only use the materials provided.<br>2. Time. |

## Lesson Plan #1

## Guiding Question - Can you devise a fair test investigation to determine which unknown salts are used in a hot pack and in a cold pack?

**Time:** 30 minutes

**Lab Preparation:**

Before students begin the fair test investigation, prepare samples of each salt. Label four (250 mL) beakers A, B, C, and D. Place approximately 25g of each salt (Sodium bicarbonate, Ammonium nitrate, anhydrous calcium chloride, and Sodium chloride) in the respective beakers. Place these beakers at the front of the room or on a central table for students to make observations.

**Procedure:**

1. Pass around examples unopened hot and cold packs.

   *Ask: Who has seen these kinds of bags before?*
   *Describe for me, where and when you have seen these bags?*
   *Does anyone know how they work?*
   *Who do you think created these types of bags?*
   *What kind of problem do you think these kinds of bags help solve?*
   *What do you think is inside each of these bags? Why? Or how do you know?*

2. Instruct students to examine the four beakers labeled A, B, C, and D.

3. Using their notebooks, instruct students to make observations of each unknown salt.

   *Ask: What kinds of observations did you make?*
   *Which salts appear more granular (or finer)?*
   *Which salts appear more course or grainy?*

4. Explain to the class that some of these salts are used in hot and cold packs.

   *Ask: How could your team come up with a way of determining which salts make a hot pack hot and a cold pack cold?*

5. Instruct students to use their notebooks to develop a procedure and a list of materials they will need to conduct an investigation to determine which salts make a hot pack hot and cold pack cold.

6. Once students have developed their plans, instruct them to share their procedures with the class. Make sure students' procedures are safe, consist of a way to collect and organize data, and include the use of all the salts.

*Option (Teacher-guided inquiry approach):* Provide a prescribed procedure and data table for students. Set up stations around the room that consist of cups of each salt labeled A, B, C, and D. Provide a thermometer, spoon, and a container of water at each station. Students add five spoonsful of water to each cup of salt and measure and record the temperature of the water after 2 minutes.

## Lesson Plan #2

## Guiding Question - Which salts make a hot pack hot and a cold pack cold?

**Time:** 30 minutes

**Procedure:**

1. Students work in lab teams to carry out their fair test investigations. Make sure students record data in their tables. Examples of tables could include the following:

*Table 1: Temperature of the solution for unknown salts A, B, C, and D*

| ***Unknown Salt*** | ***A*** | ***B*** | ***C*** | ***D*** |
|---|---|---|---|---|
| Initial temperature | | | | |
| Temperature after one minute | | | | |
| Temperature after two minutes | | | | |
| Temperature after three minutes | | | | |

*Table 2: Observations of reactions after water was added to salts A, B, C, and D*

| ***Unknown Salt*** | ***A*** | ***B*** | ***C*** | ***D*** |
|---|---|---|---|---|
| Reaction after water was added | | | | |

*Table 3: Observations of reactions after water was added to salts A, B, C, and D**

| | | |
|---|---|---|
| Observations of Salt A: | Initial temperature: _____<br><br>Final temperature: _____ | Is this a good candidate for a cold pack or a hot pack? |

**Note: Make the same table for each salt.*

2. Once students complete their investigations, instruct them to report out their results.

*Ask: Which salt(s) make a hot pack hot and cold pack cold?*
*How do you know? Based on what evidence?*
*If you had a chance to improve upon your investigation or conduct this investigation again, what would you do differently?*

Explain to students that what has taken place is a chemical reaction. In one case, the reaction caused the temperature to increase. In this case, this was an exothermic reaction. This is when heat is generated or created. In another case, the reaction caused temperature to decrease. In this case, this was an endothermic reaction which means that heat energy is actually absorbed (or taken in). (*Another possible explanation*: If the energy released is greater than the energy needed the temperature of the solution rises. If the energy needed is greater than the energy released the temperature falls.)

3. Instruct students to determine which salt(s) caused an exothermic reaction and which salt(s) caused an endothermic reaction. Discuss with students their ideas about how a hot or cold pack actually works.

4. Using this information, share with students the design challenge. Instruct students to read and review the challenge.

# Lesson Plan #3

## Design Challenge – Design Hot/Cold Pack for Children

**Time:** 30 minutes

**Procedure:**

1. Instruct students to read and review the design challenge.

   *Ask: What is the problem?*
   *Who is the client or user?*
   *What are the constraints?*
   *What do you know about exothermic and endothermic reactions?*
   *How can you use the information you learned from your investigations to solve this design challenge?*

2. Instruct students to develop their own individual plans first. Then instruct students to share their plans with team members. Students then decide on a team plan.

3. Using the materials provided, instruct students to design the pack.

4. Encourage students to test their packs and gather results to determine if their prototype is meeting the goals of the challenge and the needs of the user/client.

5. Each team then presents its prototype to the class and shares its results. Other teams provide feedback. Students are then encouraged to note the feedback and consider ways to improve upon the team's design.

   *If time permits:* Encourage student teams to redesign their prototypes and share their results with the class.

## Assessment

The following are possible sources of formative and summative assessment:

*Formative assessment:*

- Students share notebook entries from the fair test investigation (i.e, procedure, data tables, and concluding summaries) and the design challenge (i.e., individual and team design, results from testing the prototype, feedback from other teams, and redesigned prototype)

*Summative assessment:*

- Students prepare a final report of their fair test investigation that includes a statement of the question, procedure, evidence (results), and conclusion.
- Students showcase their prototypes of their respective models of a hot/cold pack.

## Lesson Extensions and Resources

**Activity Extensions:**

Instruct students to construct a hot or cold pack that could be *reusable*.

Instruct students to consider different users or clients and have them generate prototypes that meet their needs. For example, a hot pack that can be used to keep feet or hands warm while sledding, skiing or snowboarding.

**Web Resources:**

The science behind hot and cold packs:

- See: http://nobel.scas.bcit.ca/debeck_pt/science/hotColdPack/pack_p1.htm

Other examples of hot and cold pack labs:

- See: http://sciencenetlinks.com/lessons/the-transfer-of-energy-1/
- See: http://mthsscience.org/Science_fair/SF_Chemistry/Make%20Your%20Own.pdf

# Design Activity

## Student Resource

Happy Family Products is a company that is interested in providing fun and healthy products for families with small children. They need your help in designing a hot and cold pack for little children. They are looking for a new, innovative product like no others currently on the market. This product will be designed for children, though adults can use it too. The product solves the problem of how to apply cold or heat to a child's injury in the most comfortable and efficient way possible.

Until now, our options were limited – either a messy, drippy plastic bag full of ice cubes or a hot or cold (frozen hard) plastic gel pack – both painful after a few moments of direct contact with delicate, injured skin and both requiring an adult to sit and hold the bag or pack on the child's injury (or trust the child to do it themselves, often resulting in the mysterious disappearance of the bag or pack after a few short minutes).

The product should protect the skin from direct contact with the hot/cold pack, while keeping in place on the injury. That frees up busy parents, caretakers and children having to hold the hot/cold pack on an injury for long periods of time.