

Matter of Degree

Learning Objectives: *Learn about exothermic reactions (that release energy) and endothermic reactions (that absorb energy).*

GRADE LEVEL

K-8

SCIENCE TOPICS

Physical Properties
Solutions and Mixtures
Chemical Reactions

PROCESS SKILLS

Comparing and
Contrasting
Measuring
Organizing Data

GROUP SIZE

2-4

SNEAK PEAK inside ...

ACTIVITY

Mixing water with different white powders in plastic sandwich bags makes them hot and cold.

STUDENT SUPPLIES

see next page for more supplies

Epsom salts
laundry detergent
sealing plastic bags
pop-top squeeze bottles, etc....

ADVANCE PREPARATION

see next page for more details

Fill cups with powders
Fill bottles with water, etc....

OPTIONAL EXTRAS

DEMONSTRATION

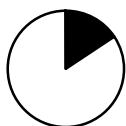
Hot and Cold Packs (p. A - 52)

EXTENSIONS

Test Other Powders (p. A - 57)
Measure Temperature Change (p. A - 57)
Vary Powder Amounts (p. A - 58)

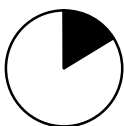
TIME REQUIRED

Advance Preparation



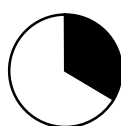
10 minutes

Set Up



10 minutes

Activity



20 minutes

Clean Up



10 minutes

SUPPLIES

Item	Amount Needed
sealing plastic bags (e.g., Ziploc™)	2 per group
plastic cups, 8 oz.	2 per group
permanent markers (e.g., Sharpie™)	1 per group
plastic spoons (e.g., teaspoon size)	2 per group
pop-top squeeze bottles (e.g., water or sports drink) 6 oz. or larger	1 per group
Epsom salts	¼ cup per group
laundry detergent (must contain sodium carbonate— available in grocery stores)	¼ cup per group

For Extension or Demonstration supplies, see the corresponding section.

ADVANCE PREPARATION

Supplies Preparation

Laundry Detergent:

- ❑ The detergent must contain sodium carbonate (also called washing soda), so not all brands will work. Check the label. Try out these detergents first: Arm & Hammer Fabricare™, BioKleen™, Seventh Generation™.

Cups:

- ❑ Label the two plastic cups for each group “D” and “E” for “Laundry Detergent” and “Epsom Salts.”
- ❑ Fill each cup with ¼ cup laundry detergent or Epsom salts.

Water Bottles:

- ❑ Fill pop-top squeeze bottles with room temperature water.

Notes and Hints

- ❑ Room temperature water is best for this experiment since it will allow the greatest range of temperature changes to be observed.

SETUP



For each group

- ❑ 2 sealing, plastic sandwich bags
- ❑ permanent marker
- ❑ plastic cup labeled "E" with $\frac{1}{4}$ cup Epsom salts
- ❑ plastic cup labeled "D" with $\frac{1}{4}$ cup laundry detergent
- ❑ 1 plastic spoon
- ❑ water in a pop-top squeeze bottle

In a central location (or with the teacher)

- ❑ sponges and towels for clean up

INTRODUCING THE ACTIVITY

Let the students speculate before offering answers to any questions. The answers at right are provided for the teacher.

In this reaction, students observe chemicals release or absorb heat when they dissolve in water.

What things in the world give off heat?

Possible answers are stoves, light bulbs, car engines, fires, people, the sun, pavement on a hot day, volcanos, friction (e.g., from rubbing hands together).

What causes the heat in these things?

Stoves and light bulbs use electricity to heat metal. In fires, a chemical reaction between the wood and air releases heat. People stay warm by the chemical reactions between their bodies and the food they eat. The sun is hot because of nuclear explosions that release heat. Finally, friction from rubbing hands releases heat by a simple mechanical process of rubbing molecules together.

For 5th-8th grades

Heat is a type of energy. Things that have this energy are hot, while those without much heat energy are cold. What things in the world do not have that much heat in them?

Possible answers are ice, fridges, snow, winters, mountain tops, Antarctica, etc. A follow up question might be: "Where did their heat go?"

TEACHER DEMONSTRATION

Hot and Cold Packs

This demonstration is best performed AFTER the students have completed their experiments.

Supplies

- ❑ Hot packs: Chemical hand warmers containing sodium acetate can be found at camping/outdoor stores. Other hand warmers may use iron filings. Follow the directions on the package for activation.
- ❑ Cold packs: These can be found at sporting good stores, drug stores, or other places where first aid items are sold. Most of these contain urea and water as the active ingredients.

Demonstration

- ❑ Pass around a hand warmer and cold pack before activation. Allow students to feel the beginning temperature.
- ❑ Activate the hand warmer and cold pack. Pass these around again so students can compare.

Explanation

Many hand warmers contain sodium acetate dissolved in water. Upon activation, the sodium acetate solidifies, releasing energy (an **exothermic** process). Others contain powdered iron that reacts with water and the oxygen in the air (that is, it rusts) to release heat.

Most cold packs contain solid urea and a small packet of water. Crushing the water packet allows the urea to dissolve in the water. This process absorbs energy so the pack feels cold (an **endothermic** process).

CLASSROOM ACTIVITY

Have students follow the Scientific Procedure on page A - 61, working in groups of 2–4. Below are suggestions to help the teacher facilitate the activity.

NOTES

Matter of Degree SCIENTIFIC PROCEDURE

This handout is
on p. A - 61.

1. Label one plastic bag "D" for laundry detergent. Label the other bag "E" for Epsom salts.
2. Add three spoonfuls of water to each bag.
 - Feel the bag. What does it feel like?
3. Add one spoonful of laundry detergent to the bag labeled "D", and gently mix the ingredients by squeezing the bag for thirty seconds.



Running Suggestions

- ❑ Students can use any size spoon to add the powders to the water in the bags. The exact amount is unimportant.
- ❑ Allow the water to come to room temperature before using it in this experiment. If the water is too cold or too hot, the temperature changes produced in this activity will be less noticeable.
- ❑ Only detergents that contain washing soda (sodium carbonate) will heat up when they dissolve in water. However, even if washing soda is on the list of ingredients, it's a good idea to try the detergent beforehand (to see how much it will warm up).

Ongoing Assessment

- ❑ Why are we squishing the bags? *(To help the powder dissolve.)*
- ❑ Which chemical is producing the temperature change—the solid or the water? How do you know? *(It's the interaction of both water and powder that produces the heat change.)*
- ❑ Which chemical changes more when they are combined? *(The powder—it changes state, changes color; the water also rearranges to accommodate the powder, but it mostly stays the same color and the same state [liquid].)*

Safety and Disposal Information

- ❑ Used bags with their solutions may be thrown in the trash.

CLASSROOM DISCUSSION

Ask for student observations and explanations. Let the students guide the discussion and present their hypotheses before discussing explanations.

Choose questions that are appropriate for your classroom.

What happened to the powders when you added them to water? What happened to the water?

The two powders dissolved in the water. The water that was dissolving detergent warmed up, while the water dissolving Epsom salts got cold.

What would happen if you did this same experiment again with a different amount of water? Would the temperature change? What about a different amount of powder?

Increasing the water reduces the temperature change. The same amount of heat is released or absorbed, but there is more water to heat or cool. Differing amounts of powder also affect the temperature change for similar reasons.

Which powder released energy in the water? Which one absorbed energy?

The detergent (the warm solution) released energy into our hands, which we felt as heat. The Epsom salts (the cold solution) absorbed energy from our hands. We feel the loss of energy from our hands as "cold."

Do you have to add energy to dissolve detergent in water? What about Epsom salts?

Detergents become warm when they dissolve in water, so they must release some excess energy. This energy warms up the water. Epsom salts need energy to dissolve. They take it from the room temperature water (which has lots of heat compared to, say, water at the North Pole), making the water colder.

How might heating or cooling reactions help us in everyday life?

First aid cold packs or heat packs, de-icers for roads or airplane wings, etc. Also, many of the chemical reactions in our bodies (such as digesting food) produce heat—this keeps us warm and helps our brains and bodies work. When we exercise, the increased chemical reactions in our muscles heat us up more.

What other chemical reactions produce heat? Can you think of any reactions that absorb heat?

When wood, paper, or gasoline burn, those chemical reactions produce heat. The heat from burning gasoline helps to move the pistons in a car engine, making the wheels turn. Reactions that absorb heat are more rare, but dissolving baking soda in water is an everyday example (see Extension A).

EXPLANATION

This background information is for teachers. Modify and communicate to students as necessary.

When chemicals combine in new arrangements, they often exchange energy. In this experiment, students discover how dissolving solids in water releases or absorbs energy.

BACKGROUND FOR ALL GRADES

Dissolving powders and temperature changes

When students add detergent and Epsom salts to water, the powders break apart and spread out in the water (i.e., they **dissolve** in the water). This causes the solution temperature to change.

When it dissolves, each powder molecule detaches from other powder molecules and becomes surrounded by water molecules. This change in arrangement either absorbs or releases **energy**. The exchange of energy causes the temperature of the solution to change. When the powder molecules release energy in the solution, it heats up. When powder molecules absorb energy from the solution, it cools down. Students detect the change of energy as a change in temperature.

Misconception Alert: Note that this change in energy happens whenever any solid dissolves in water, even table salt. Detergent and Epsom salt are used in this experiment because they produce noticeable changes in temperature with only small amounts of powder.

Also note that technically, no chemical reaction is occurring (i.e., the powders don't change into something new, and neither does the water). Instead, the

molecules are just arranged in a different way, and, in moving to their new arrangement, they either release or absorb energy.

EXTRA BACKGROUND FOR GRADES 6–8

Temperature is Motion

What does it mean to be “hot” or “cold”? If students could look at the “cold” Epsom salt molecules in solution and the “hot” detergent molecules in solution, they would notice something right away. The “hot” detergent and water molecules would all be moving, spinning, and shaking much faster than the “cold” molecules in the Epsom salt solution. In fact, when scientists say a substance is “hot,” what they mean is the molecules in that substance are shaking and moving a lot. In general, scientists define **temperature** as the average molecular motion of a substance. Cold substances have less molecular motion (including vibration) than hot substances.

Because molecules are so tiny, students can never feel them moving. Yet by feeling the temperature, students are indirectly experiencing what happens when billions and billions of molecules move, shake, and twist.

Exothermic and Endothermic Processes

The energy changes in this experiment come from rearranging atoms and molecules. In general, when molecules move from high-energy arrangements to low-energy arrangements, they release energy.

This is what happens when the detergent (containing sodium carbonate molecules in a high energy arrangement) dissolves in water. The sodium carbonate molecules are rearranged in the water, releasing energy as heat. This transfer of heat out of a chemical system is called an **exothermic** process.

The opposite process occurs when Epsom salts, which are in a lower-energy arrangement, dissolve in water. These molecules make up the energy difference by absorbing energy from the surrounding solution. This cools the water down and makes the bag feel cool. The transfer of heat into a system (in this case, to the Epsom salt molecules from the water itself) is called an **endothermic** process.

Misconception Alert: It's important to note that cold is simply the relative absence of heat. We detect “cold” when we touch something cold because the colder object transfers heat out of our hands.

EXTENSIONS

Extension A: Test Other Powders

Other chemicals also release or absorb energy when dissolved in water.

Extra Supplies

- ❑ plastic cups (3 per group)
- ❑ resealing plastic bags (3 per group)
- ❑ plaster of Paris ($\frac{1}{4}$ cup per group)
- ❑ baking soda ($\frac{1}{4}$ cup per group)
- ❑ calcium chloride ($\frac{1}{4}$ cup per group)

NOTE: Calcium chloride (CaCl_2) is available as a de-icer (brands ComboTherm and Road Runner) or as a dehumidifier (brands Damp Rid or Dry Z Air). Other brands may work too, look on the side panel, and test other brands before using in class.

Extra Instructions

- ❑ Label and fill extra plastic cups with plaster of Paris, baking soda, and calcium chloride. Cover until ready for use.
- ❑ Follow the Scientific Procedure on p. 10, using these materials instead of Epsom salts and laundry detergent
- ❑ NOTE: plaster of Paris takes 10–12 minutes to react and become warm.

Explanation

The calcium chloride and the plaster of Paris both get warm when dissolved in water. Baking soda gets cold.

CAUTION: Calcium chloride can get VERY hot when dissolved in water (150–190°F). This may be too hot to comfortably handle.

Extension B: Measuring Temperature Change

Students measure the temperature change of the solutions using thermometers and Styrofoam cups. Older students can graph the results of a time series of measurements.

Extra Supplies

- ❑ thermometers (1 per group)
- ❑ Styrofoam cups (2 per group)

Extra Instructions

- ❑ Students can practice designing an investigation and measuring and graphing (older students) their results by using thermometers and Styrofoam cups.

- ❑ If possible, facilitate a student discussion of when to measure the temperature change, how to display results (bar graph? table?), how much water to use, how to use the thermometer, etc.
- ❑ Remind students to record the temperature of the water before adding any chemicals. Have students graph their results.

Extension C: Vary Amounts of Powder

Students compare temperature change with differing amounts of solid using thermometers and Styrofoam cups. They can then measure the temperature change as in Extension B, and older students can graph those changes.

Extra Supplies

- ❑ thermometers (1 per group)
- ❑ Styrofoam cups (8–12 per group, depending on how many amounts are investigated)
- ❑ one $\frac{1}{8}$, $\frac{1}{4}$, or $\frac{1}{2}$ teaspoon measure (to produce a number of different solid amounts) (Note that with a single $\frac{1}{8}$ teaspoon, students can measure $\frac{1}{8}$, $\frac{1}{4}$, $\frac{3}{8}$, $\frac{1}{2}$, $\frac{5}{8}$, etc., teaspoons of the powders.)

Extra Instructions

- ❑ This extension is very similar to Extension B above, except that students vary the amount of solids that dissolve in the same amount of water.
- ❑ Discuss how to set the experiment up with the students, being sure to ask older students how to collect their results (i.e., in a graph, on a chart?) since there will be many different results from this investigation.
- ❑ Students should prepare data collection sheets and label their cups.
- ❑ **Note:** It is important that students measure the starting temperature of the water before they add any powder. For instance if students use the $\frac{1}{8}$ teaspoon six times to measure $\frac{3}{4}$ teaspoon of solid, the solution temperature changes with each addition. So the starting temperature is BEFORE they added the first $\frac{1}{8}$ teaspoon of powder.
- ❑ If students find they can't change the temperature any more, ask them to hypothesize why.

Explanation

The more powder that dissolves, the more the temperature will change, up to a point. When the water can't dissolve any more powder, adding more powder won't really affect the temperature. It is the process of dissolving that changes the temperature. Note that the solubility of the powder in the water is affected by temperature. As the water warms up, it can hold more detergent. Conversely, when it cools down, the water can dissolve less Epsom salt. This effect complicates the results of the experiment but can provide an interesting discussion that may lead to further experimentation.

CROSS-CURRICULAR CONNECTIONS

BIOLOGY

Hypo- and Hyperthermia

Have students research hypo- and hyperthermia.

MATHEMATICS

Graphing Temperature Change

Complete Extension B or Extension C. Graph results.

LANGUAGE ARTS

Extreme Environments

Have students read books set in extreme temperature environments. These may be novels or factual accounts of survival in these areas.

Extremely cold environments: Antarctica, Iceland, Greenland, the Arctic, Mars. Extremely hot environments: Tunisia, Coober Pedy, Australia, the Sahara Desert, Venus.

RESOURCES

Lerangis, Peter, *Antarctica: Journey to the Pole*

Reading Level: 3rd to 8th grade

An exciting novel packed with thoroughly researched information. Each chapter told from a different crew member's point of view.

Raskin, Lawrie, *52 Days by Camel: My Sahara Adventure*

Reading Level: 4th to 8th grade

Photographer Lawrie Raskin traveled to Timbuktu from Fez on a series of excursions riding buses, jeeps, trucks, a train, and a camel. Lively narrative. There are maps for each leg of the journey that are color coded with dots that match accompanying text. Also includes cultural information about survival in this extreme environment. Clear, bright, full-color photos abound.

Ryan, Zoe Alderfer, Ann and Liv Cross *Antarctica: Dream Come True*

Reading Level: 3rd to 8th grade

A factual account of the Bancroft Arnesen Expedition across Antarctica aimed at ages 9–12.

Forgey, William, *Basic Essentials: Hypothermia*

Reading Level: 4th to 8th grade

An information-packed tool for the novice or handy reference for the veteran. Distills years of knowledge in an affordable and portable book.

VOCABULARY

dissolve:	when the molecules of a substance separate and become completely surrounded by the molecules of another substance
endothermic:	a process that absorbs energy, causing it to feel cool; <i>endo</i> means <i>into</i>
energy:	the ability to do work; anything that is not matter
exothermic:	a process that releases energy, causing it to feel warm; <i>exo</i> means <i>out of</i> .
temperature:	a measure of the energy of a substance, based on how fast its molecules are moving

Matter of Degree

SCIENTIFIC PROCEDURE

1. Label one plastic bag "D" for laundry detergent. Label the other bag "E" for Epsom salts.
2. Add three spoonfuls of water to each bag.
 - Feel the bags. What do they feel like?
3. Add one spoonful of laundry detergent to the bag labeled "D". Seal the bag and gently mix the ingredients by squeezing the bag for 30 seconds.
 - What does the bag feel like now?
4. Add one spoonful of Epsom salts to the bag labeled "E". Seal the bag and gently mix the ingredients by squeezing the bag for 30 seconds.
 - What does the bag feel like now?
5. Compare the two bags.
 - How are the contents of the two bags the same?
 - How are the contents of the two bags different?
6. Clean up your area.
 - Follow your teacher's instructions.



This worksheet is available online at www.oms.edu/k8chemistry.

A Matter of Degree

Recommended group size: 2–4

Number of Students: Number of Groups:

Supplies	Amount Needed	Supplies on Hand	Supplies Needed
sealing plastic bags (e.g., Ziploc™)	2 per group		
small plastic cups	2 per group		
permanent markers (e.g., Sharpie™)	1 per group		
spoon (e.g., teaspoon size)	2 per group		
pop-top squeeze bottles (e.g., water or sports drink) 6 oz. or larger	1 per group		
Epsom salts	¼ cup per group		
laundry detergent (must contain sodium carbonate—available in grocery stores)	¼ cup per group		
Extension A			
plastic cups	3 per group		
sealing plastic bags	3 per group		
plaster of Paris	¼ cup per group		
baking soda	¼ cup per group		
calcium chloride	¼ cup per group		
Extension B			
Styrofoam cups	2 per group		
thermometers	1 per group		
Extension C			
thermometers	1 per group		
Styrofoam cups	8–12 per group depending on how many amounts are investigated		
⅛ teaspoon measure	1 per group		
¼ teaspoon measure	1 per group		
½ teaspoon measure	1 per group		

Supply Worksheet continues on next page.

Supplies	Amount Needed	Supplies on Hand	Supplies Needed
Teacher Demonstration			
Hot and Cold Packs			
Hot packs: Chemical hand warmers containing sodium acetate can be found at camping/outdoor stores. Other hand warmers may use iron filings. Follow the directions on the package for activation.	1–2 per class		
Cold packs: These can be found at sporting good stores, drug stores, or other places where first aid items are sold. Most of these contain urea and water as the active ingredients.	1–2 per class		

