Understanding Temperature & Chemical Change

Major Topic and SOL Temperature and chemical changes
Science SOL PS.1, PS.2, PS.5, PS.7

Length of Unit **3 -50 minute class periods**

Major Understanding
Students will understand

- Temperature is the measure of the average kinetic energy
- Temperature is measured in the SI unit Celsius
- Why we need to measure temperature
- How to measure temperature using Vernier temperature probe
- How to create a graph using Vernier program
- Compare Vernier temperature probe to regular thermometer
- Matter is anything that has mass and takes up space
- Matter can undergo physical and chemical changes. In physical changes, the chemical composition of the substances does not change. In chemical changes, different substances are formed.
- Chemical reactions are classified into two broad types: ones in which energy is released (exothermic) and ones in which energy is absorbed (endothermic)

Essential Questions

- What is temperature?
- What instruments can measure temperature?
- Why do we need to measure temperature?
- How can you describe matter?
- How can we distinguish between chemical and physical properties/ changes?
- What is an example of an endothermic reaction?
- What is an example of an exothermic reaction?

Student Objectives
Students will be able to:

- Identify temperature and the instrument used to measure it
- Create and interpret temperature graphs
- Compare, contrast and identify chemical changes/properties of matter
- Identify when energy is released (exothermic) and when energy is absorbed (endothermic) during phase changes

Lesson Contributed by: Kimberly Bosiger
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Bloom's Taxonomy Skills	**21st Century Learning Skills**
• Creating • Evaluating • Analyzing • Applying • Understanding • Remembering	• Critical Thinking • Problem Solving • Communication • Collaboration • Information & Media

Assessment Evidence

Performance Tasks

Students will

- Identify temperature verbally
- Exhibit a comprehension through discussions
- Identify temperature of cold, hot and room temperature water using Vernier probeware and regular thermometers
- Create temperature graph
- Differentiate between chemical and physical changes
- Distinguish between endothermic and exothermic reactions
- Classify reactions as energy absorbing (endothermic) or energy releasing (exothermic) on the basis of temperature measurements

Other Evidence

- Data recorded
- Graphs created
- Oral responses

Technology computers, Internet connection, projection system, speakers, document camera, temperature probes, Logger Lite software

Internet Resources

- http://blog.globe.gov/sciblog/2008/10/ (cricket chart – also available for print at end of lesson plan with resources)
- http://www.enchantedlearning.com/science/temperature/
- http://www.teachersdomain.org/resource/lsps07.sci.phys.matter.dissolvesalt/

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Supplies/Materials

- Vernier temperature probe and software
- Regular thermometers
- Hot & cold pack
- Materials* for Endothermic and Exothermic Reactions lab activity
- Materials* for Learning to use GO! Temp Elementary Science with Vernier worksheet
- Materials* for Why do we need thermometers? Elementary Science with Vernier worksheet
- Worksheet simulation, "Which salts make good cold and hot packs?"

* See lab worksheets for supplies for each lab

Lesson 1: Understanding Temperature (2 – 50 minute periods)

Engage:

- Did you know that you can tell the temperature by counting the chirps of a cricket? It's true! Here's the formula:

To convert cricket chirps to degrees Celsius, count the number of chirps in 15 seconds, add 9, and then divide by 2 to get temperature.
Example: 17 chirps + 9/2 = 13° C

- Look at this graph and see what the relationship is between cricket chirps and temperature

Explore:

- Students will read about thermometers: http://www.enchantedlearning.com/science/temperature/ (you could also find a short video to show your students if you have a subscription to BrainPop or Discovery Education)
- Students will investigate and observe actual thermometers and notice the liquid inside
- Participate in Learning to use GO! Temp and Why do we need thermometers?

Explain:

- Temperature measures the motion of molecules in a substance.
- Thermometers have a liquid inside that expands when heated.
- Celsius, Fahrenheit and Kelvin are different temperature scales
- Celsius:
  30 is hot
  20 is nice
  10 is chilly
  0 is ice

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Elaborate:

- **Question:** When do we measure temperature and why?
  Answers may include: We measure heat outside to decide what to wear or to be prepared for ice or snow. We measure the temperature of the refrigerator to make sure that food doesn't go bad. We measure the temperature of the oven so that we can bake food evenly. We measure the temperature of our bodies to see if we have a fever.
- **Question:** How do we measure temperature?
  Answer: We use a thermometer to measure temperature. The liquid inside of the thermometer expands when it becomes hotter and contracts when it becomes cooler. The amount that it expands or contracts is measured with a certain scale:
  Celsius, Fahrenheit or Kelvin.
- **Question:** Why do we need thermometers?
  Answer: We need thermometers to accurately measure temperature. Without them, we meteorologist wouldn't be able to accurately report the weather and we wouldn't know what to wear each day. Without them, we wouldn't be able to tell how sick a person was or if the oven is ready to cook our food. We even need thermometers to ensure that our food is cooked properly so not to get food poisoning or salmonella.

Evaluate:

- Questioning of students during the discussion will show how well they observed and understood the experiment. Also, student understanding will be shown by their participation in the lab activity which asks them to show their understanding of how and why we need thermometers. Skill outcomes include recording data and creating a graph from their data. They will be graded on their worksheet, graphs, and data.

Lesson 2: Hot and Cold (1 – 50 minute period)

Engage:

- Hold up and introduce hot and cold packs. Ask the class: What are they used for? What do they do? How do they work?
- Start the reactions and pass the packs around the room- tell students they get three seconds to hold a pack before they pass it along.
- **Question**: Why do you feel a change in temperature?
  Answer: A chemical reaction is taking place and the change in temperature verifies that.

Notes on Hot and Cold Packs:

Hot and cold packs demonstrate endothermic and exothermic processes. A cold pack can be stored at room temperature, but within seconds can become cold enough to ice an injury. Hot packs meanwhile are often used as hand-warmers in the winter. You can carry them in your pocket until you are ready to activate them, and they will then stay warm for 15 minutes to half an hour.

A typical cold pack consists of two chambers, one containing water and the other containing a chemical like ammonium nitrate. When you break the bag, the two chambers combine and the ammonium nitrate dissolves in the water. This generates a chemical reaction. This particular reaction is endothermic, which means that heat is absorbed. The absorption of heat causes the pack to get cold. A hot pack works in the same way, except it uses a chemical that reacts with water exothermically, which means that heat is given off. Calcium chloride and magnesium sulfate are typical choices for this chemical. Both hot packs and cold packs will last for about twenty minutes on average.

Explore:

- Tell the class: In today's activity, we are going to discover if several chemicals would be good ingredients in a hot or cold pack. Ask the following questions and write their responses to the last three on the board under the titles "materials", "safety", and "data".
  - How will you know if a chemical is a good chemical to use in a hot pack?...in a cold pack? (gets hot or cold)
  - What materials would you need? (water, thermometer, container, …)
  - What about materials for safety? (goggles, gloves, aprons)
  - What kind of data would you record? (temperature, time)
- Explain that the students will be working in groups to complete a *dry lab.* They will be completing the worksheet/activity, "Which salts make good cold and hot packs?", in small groups using a simulation.

Explain:

- Review the information recorded in the worksheet/activity, "Which salts make good cold and hot packs?", and make sure to cover these points:
  - Matter is anything that has mass and takes up space
  - Matter can undergo physical and chemical changes. In physical changes, the chemical composition of the substances does not change. In chemical changes, different substances are formed.
  - Chemical reactions are classified into two broad types: ones in which energy is released (exothermic) and ones in which energy is absorbed (endothermic)
  - Changes in temperature occur during these chemical reactions.
  - Measured temperatures show the difference between an exothermic and endothermic reaction

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Elaborate:

- **Question:** What are some everyday processes that occur due to endothermic reactions taking place?
  Answers may include: melting ice cubes, evaporation of water, baking/cooking foods, photosynthesis
- **Question:** What are some everyday processes that occur due to exothermic reactions taking place?
  Answers may include: freezing ice cubes, formation of snow, burning candles, burning a fire

Evaluate:

- Questioning of students during the discussion will show how well they observed and understood the experiment.
- Student understanding will be shown by their participation in the lab activity which asks them to show their understanding of an increase and decrease in temperature and the type of reaction created by each.
- Skill outcomes include recording and interpreting data.
- They will be graded on their worksheet and data.

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Which salts make good cold and hot packs?

Introduction

You have been hired as a consultant to a company that manufactures cold and hot packs, which are used to treat minor injuries. The company recently received a large amount of salts to use as possibilities in the manufacture of their products. Your job is to identify which of these salts is best suited for production of a hot pack and a cold pack.

Procedure

This is a dry lab that uses a computer simulation to perform the trials necessary to evaluate each of the salts. You will need to visit the following site to access the simulation program: http://www.teachersdomain.org/resource/lsps07.sci.phys.matter.dissolvesalt/.

This URL takes you to a page entitled "Dissolving Salts in Water". Click the "View" button and perform each of the trials shown below. Use the dropdown menu to choose the desired salt. The "slide bars" should be used to adjust the mass of salt and the volume of water used in each trial. Be sure to record the initial temperature, the mass of solution (mass of water + mass of salt), the final temperature, and the change in temperature in the data table below. Once you have performed a trial, you will need to click the "Reset Solution" button in order to go on to the next trial.

All salts are ionic compounds, made of positive and negative ions. The process of dissolving a salt in water involves three main steps: breaking the ionic bonds of the salt, breaking the network of water molecules apart in the bulk solvent, and bonding water molecules to the ions (this process is called hydration). As with any chemical reaction where bonds are broken or formed, energy (generally in the form of heat) is involved. As a solute dissolves, the heat of solution can be measured as a change in the temperature of the solution. If the process of dissolving absorbs heat, *the temperature of the solution decreases* and the heat of solution is described as **endothermic**. On the other hand, if the process of dissolving releases heat, *the temperature of the solution increases* and the heat of solution is described as **exothermic**.

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Data Table

Trial	Salt	Mass used (g)	Volume of water (mL)	Mass of solution (g)	Initial Temp. (^oC)	Final Temp. (^oC)	ΔT (^oC)	Endo- or Exothermic
1	LiCl	4.8	100					
2	KCl	4.8	100					
3	NH_4Cl	4.8	100					
4	$CaCl_2$	4.8	100					
5	NaCl	4.8	100					
6	NaOH	0.5	100					
7	NaOH	1.0	100					
8	NaOH	0.5	50					

The general reaction of dissolving a salt in water (dissolution) is represented below. MA represents the salt, where M is any metal cation and A is a non-metal anion:

$$M_xA_y\ (s) \rightarrow x\ M^{y+}\ (aq) + y\ A^{x-}\ (aq)$$

Complete the following dissolution reactions for the salts tested in this experiment:

Salt	Dissolution Reaction
LiCl (s)	→
NH_4Cl (s)	→
KCl (s)	→
NaCl (s)	→
$CaCl_2$ (s)	→
NaOH (s)	→

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In order to evaluate which of the salts is best suited for use in hot/cold packs, you must calculate the heat (q) released/absorbed in the dissolution process. The following equation may be helpful for your calculations: $q = -mc\Delta T$, where m is the mass of solution (salt + water), c is the specific heat of the solution (assume 4.18 J/g●°C), and ΔT is the final solution temperature minus the initial solution temperature.

Results Table

Trial	Salt	Mass used (g)	Mass of water (g)	Heat (q) absorbed/ released (J)
1	LiCl	4.8	100	
2	KCl	4.8	100	
3	NH_4Cl	4.8	100	
4	$CaCl_2$	4.8	100	
5	NaCl	4.8	100	
6	NaOH	0.5	100	
7	NaOH	1.0	100	
8	NaOH	0.5	50	

Discussion Questions

1. Of the first 5 salts tested (trials 1-5), which salt would be most suited for use in a hot pack? Justify your answer.
2. Of the first 5 salts tested (trials 1-5), which salt would be most suited for use in a cold pack? Justify your answer.
3. Looking at trials 6 and 7, what effect did changing the amount of salt have on the heat?
4. Looking at trials 6 and 8, what effect did changing the volume of water have on the heat?

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Which salts make good cold and hot packs? (Teacher Key)

Introduction

You have been hired as a consultant to a company that manufactures cold and hot packs, which are used to treat minor injuries. The company recently received a large amount of salts to use as possibilities in the manufacture of their products. Your job is to identify which of these salts is best suited for production of a hot pack and a cold pack.

Procedure

This is a dry lab that uses a computer simulation to perform the trials necessary to evaluate each of the salts. You will need to visit the following site to access the simulation program: http://www.teachersdomain.org/resource/lsps07.sci.phys.matter.dissolvesalt/.

This URL takes you to a page entitled "Dissolving Salts in Water". Click the "View" button and perform each of the trials shown below. Use the dropdown menu to choose the desired salt. The "slide bars" should be used to adjust the mass of salt and the volume of water used in each trial. Be sure to record the initial temperature, the mass of solution (mass of water + mass of salt), the final temperature, and the change in temperature in the data table below. Once you have performed a trial, you will need to click the "Reset Solution" button in order to go on to the next trial.

All salts are ionic compounds, made of positive and negative ions. The process of dissolving a salt in water involves three main steps: breaking the ionic bonds of the salt, breaking the network of water molecules apart in the bulk solvent, and bonding water molecules to the ions (this process is called hydration). As with any chemical reaction where bonds are broken or formed, energy (generally in the form of heat) is involved. As a solute dissolves, the heat of solution can be measured as a change in the temperature of the solution. If the process of dissolving absorbs heat, *the temperature of the solution decreases* and the heat of solution is described as **endothermic**. On the other hand, if the process of dissolving releases heat, *the temperature of the solution increases* and the heat of solution is described as **exothermic**.

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Data Table

Trial	Salt	Mass used (g)	Volume of water (mL)	Mass of solution (g)	Initial Temp. (^oC)	Final Temp. (^oC)	ΔT (^oC)	Endo- or Exothermic
1	LiCl	4.8	100	104.8			9.59	Exo
2	KCl	4.8	100	104.8			-2.53	Endo
3	NH_4Cl	4.8	100	104.8			-3.11	Endo
4	$CaCl_2$	4.8	100	104.8			8.18	Exo
5	NaCl	4.8	100	104.8			-0.75	Endo
6	NaOH	0.5	100	100.5			1.32	Exo
7	NaOH	1.0	100	101			2.64	Exo
8	NaOH	0.5	50	50.5			2.64	Exo

The general reaction of dissolving a salt in water (dissolution) is represented below. MA represents the salt, where M is any metal cation and A is a non-metal anion:

$$M_xA_y\ (s) \rightarrow x\ M^{y+}\ (aq) + y\ A^{x-}\ (aq)$$

Complete the following dissolution reactions for the salts tested in this experiment:

Salt	Dissolution Reaction
LiCl (s)	$\rightarrow Li^+ (aq) + Cl^- (aq)$
NH_4Cl (s)	$\rightarrow NH_4^+ (aq) + Cl^- (aq)$
KCl (s)	$\rightarrow K^+ (aq) + Cl^- (aq)$
NaCl (s)	$\rightarrow Na^+ (aq) + Cl^- (aq)$
$CaCl_2$ (s)	$\rightarrow Ca^{2+} (aq) + 2\ Cl^- (aq)$
NaOH (s)	$\rightarrow Na^+ (aq) + OH^- (aq)$

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In order to evaluate which of the salts is best suited for use in hot/cold packs, you must calculate the heat (q) released/absorbed in the dissolution process. The following equation may be helpful for your calculations: $q = -mc\Delta T$, where m is the mass of solution (salt + water), c is the specific heat of the solution (assume 4.18 J/g●°C), and ΔT is the final solution temperature minus the initial solution temperature.

Results Table

Trial	Salt	Mass used (g)	Volume of water (mL)	Heat (q) absorbed/ released (J)
1	LiCl	4.8	100	-4201
2	KCl	4.8	100	1108
3	NH_4Cl	4.8	100	1362
4	$CaCl_2$	4.8	100	-3583
5	NaCl	4.8	100	329
6	NaOH	0.5	100	-555
7	NaOH	1.0	100	-1115
8	NaOH	0.5	50	-557

Discussion Questions

1. Of the first 5 salts tested (trials 1-5), which salt would be most suited for use in a hot pack? Justify your answer.
2. Of the first 5 salts tested (trials 1-5), which salt would be most suited for use in a cold pack? Justify your answer.
3. Looking at trials 6 and 7, what effect did changing the amount of salt have on the heat?
4. Looking at trials 7 and 8, what effect did changing the volume of water have on the heat?

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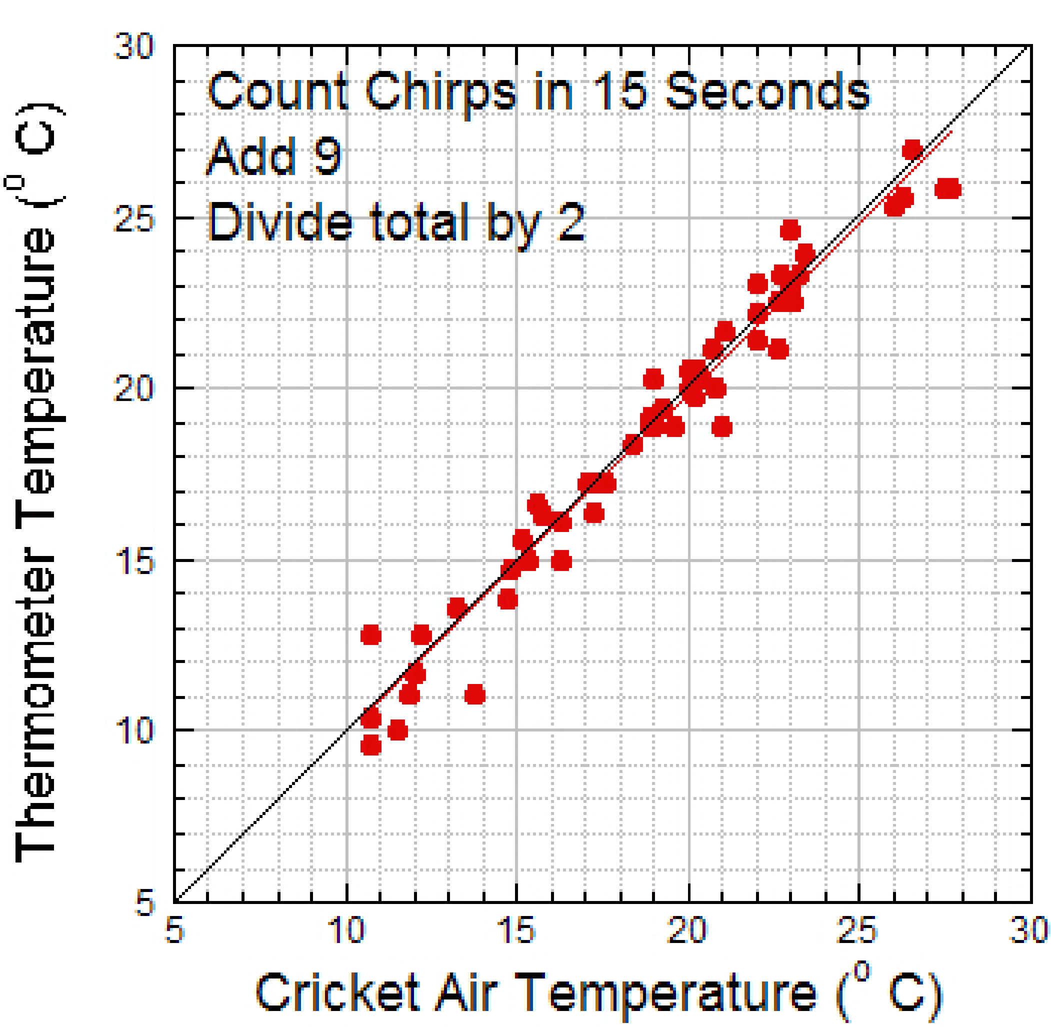
Count Chirps in 15 Seconds
Add 9
Divide total by 2
Thermometer Temperature (° C)
Cricket Air Temperature (° C)
5
10
15
20
25
30