MiSP PHASE CHANGES
Teacher Guide, L1 – L3

Introduction

Several related areas of physical science may be addressed in this unit: melting and freezing points; relative motion of particles in solids, liquids, and gases; characteristics of solids, liquids, and gases; physical change; relationship between particle motion and temperature; expansion and contraction of matter with a special note about water; and phase change.

The primary focus of the unit is phase changes and the phase change graph. The other, related topics above can be addressed on day 1, reviewed on day 1, or only partially addressed on day 1.

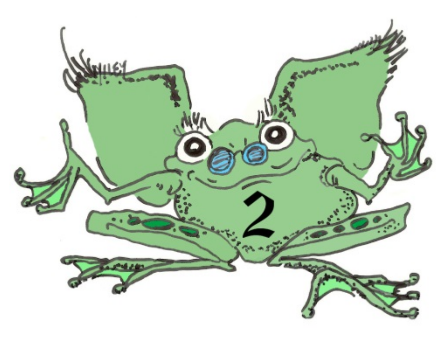
A challenge to the teaching and learning in this unit is that the two lab activities will probably not produce true horizontal (slope / unit rate of change = 0) sections. Therefore, the unit's inquiry approach—that students should discover that changes of phase occur when the temperature is not changing—will not be easy to implement. Therefore, in the latter part of the unit, instruction may be necessary with an ideal phase change graph.

Standards

ILST Core Curriculum — Major Understandings:
Standard 4 Physical Setting 3.1a, 3.1c, 3.1d, 3.1e, 3.1f, 3.2a, 3.3b, 4.2c, 4.2d

Primary Learning Objectives: After completing this unit, students will be able to:

- Define *melting point* (*temperature*), *freezing point*, *boiling point*, *condensation*, and *evaporation*
- Explain that as temperature increases, molecular motion increases
- Compare the relative motion of particles and relative temperature in solids, liquids, and gases
- Interpret a phase change graph and select where each phase is, where phase changes occur, where temperature changes, and where temperature remains the same
- Compare the flow of heat into a melting or boiling substance with the flow of heat out of a substance that is condensing or freezing
- Quantify the changes in temperature prior to phase change by calculating unit rate of change (slope) (L2)
- Compare the slope of the phase change graph when a phase change is occurring to the slope when it is not occurring (L2)



- Calculate the formula for the lines that are extended from the line segments on a phase change graph (L3).

Secondary Learning Objectives: (Part of the core curriculum but may be taught outside this unit) After completing this unit, students will be able to:

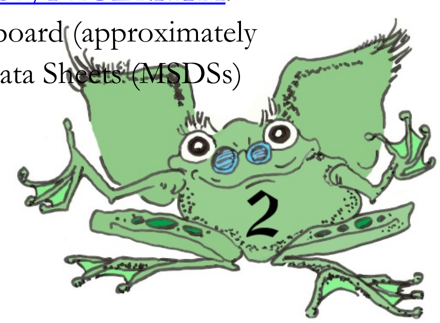
- Compare the volume and shape of solids, liquids, and gases
- Explain that a phase change is a physical change because no new substance(s) is (are) formed
- State that some substances are solid at room temperature, some are liquid, and some are a gas
- Explain that the relative strength of the attractions between molecular particles in different substances determines whether phase change temperatures are higher or lower
- State that most substances expand when heated and contract when cooled and that water is an exception near its freezing point.

There are many Internet resources; see the last page of this guide for a list of some that you may find especially helpful.

Day 1 — Introductory Lesson

Discussion Topics:

- What is the difference between a solid, a liquid, and a gas? (Answers include volume, shape, relative temperatures, and relative motion of particles.)
- What is temperature? (Consider using one or more of the websites at the end of this document to answer the question.)
- What are freezing, melting, condensation, and boiling (evaporation)? There may be some confusion about boiling and evaporation since evaporation (and even sublimation) occurs at all temperatures and boiling has a specific temperature associated with it. Also, students sometimes think that the freezing and melting temperatures of substances are different.
- Start to build an understanding that heat and temperature are not the same thing. Demonstrate the heat flow that occurs with phase changes using these activities:
    - Melt wax and let it cool.
    - Boil water over a hot plate or Bunsen burner.
    - Do "The Sticky Board" demonstration [see Liem, Tik L., 1987, *Invitations to Science Inquiry*, 5.34 / p. 169] and http://jchemed.chem.wisc.edu/JCESoft/CCA/CCA3/MAIN/ENDO2/PAGE1.HTM. You will need barium hydroxide and ammonium thiocyanate, a small board (approximately 10 x 10 cm), a beaker, and a stirring rod. Review the Material Safety Data Sheets (MSDSs)



for the two chemicals (both are toxic) and make sure you know how to dispose of the chemicals. The jchemed website has videos if you do not wish to do the demonstration. Be aware that students struggle with the idea of heat flow. They will often think that water freezes in the freezer because the cold seeps into the water. It is hard for them to conceptualize that water gives up something (heat) when it freezes.

Question of the Day:

When a person combines ice (solid water) and a glass full of liquid water, the ice usually melts. The ice does not cause the liquid water to freeze. Why? Explain this observation by talking about the flow and the amount of heat (thermal energy) contained in the ice and the liquid water and the roles that heat (thermal energy) plays in the phase changes of melting and freezing.

Day 2 — Freezing Temperature of Stearic Acid

This lab activity will be conducted as a demonstration so that it can be completed in one day. If a school has computer probeware, a temperature probe may be used.

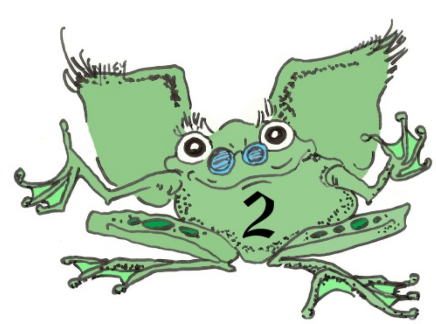
You should use reagent grade stearic acid. **A technical note from Flinn Scientific, Inc., states:** *Laboratory grade stearic acid is actually 50% stearic acid and 45% palmitic acid; melting point is 55ºC–56ºC. Reagent grade is >95% stearic acid: melting point is 67ºC–69ºC. The reagent grade is a better choice for melting point labs.*

Safety:

- Review the MSDS for stearic acid.
- Wear safety goggles.

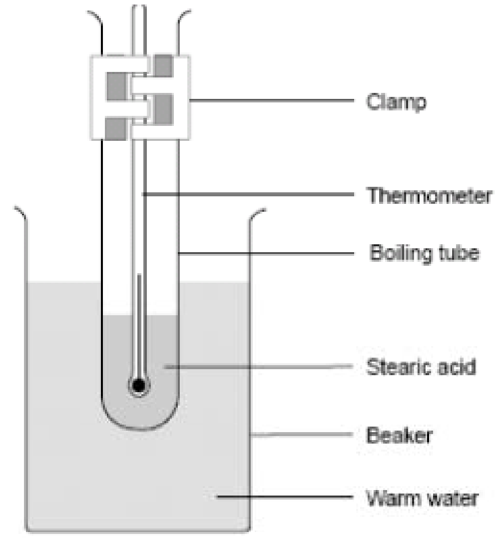
Other substances (water, etc.) may be used instead of stearic acid, and the worksheet should be adjusted accordingly. Note that the second activity uses water so a material other than water in this activity helps students understand that different substances have different melting and boiling points.

The two MiSP activities, as presented, allow students to experiment with heating and cooling and two different substances.



Introduction:

In this experiment, a solid is melted and then cooled to determine its freezing point.



What to do:

1. Set up the apparatus as shown. Fill a 250 ml beaker with about 150 ml tap water.

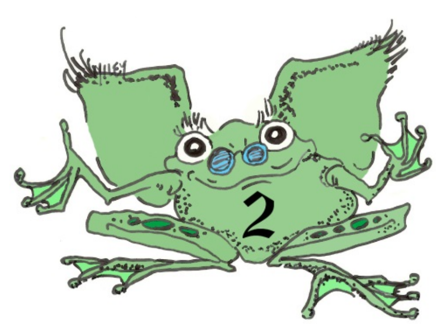
2. Heat the beaker on a tripod and gauze until the stearic acid is completely melted and the temperature is between 75ºC and 80ºC. Do not overheat; the acid will take too long to cool.

3. Use the clamp to lift the tube from the hot water. The class should record the temperature every 30 seconds as the stearic acid cools until it reaches about 50ºC. Use the thermometer to stir the liquid before each reading. Readings should be made from the center of the tube. Point out the temperature when the first signs of solid formation are observed and when the mass is completely solid.

Students should put their data on and complete Worksheet #1a. Expect to have to help them draw the best-fit lines for the cooling and the solidification part of the graph. There is a Worksheet #1b that has an ideal cooling curve graph for stearic acid. Do not distribute it until the individual students or lab groups ask for it.

Question of the Day:

Besides ice and liquid water, what other examples of melting and freezing are part of your everyday life? You may come up with only one or two. Why are melting and freezing (liquefying and solidifying) of most substances not part of our everyday lives?



Days 3 and 4 — Boiling Point of Water

Overview:

Students will heat a sample of water and record the temperature as the water heats and boils.

Procedure notes:

Bunsen burners or hot plates may be used. **Inexpensive hot plates must be set on “High” to provide a constant supply of heat.**

Computer probe ware may be used.

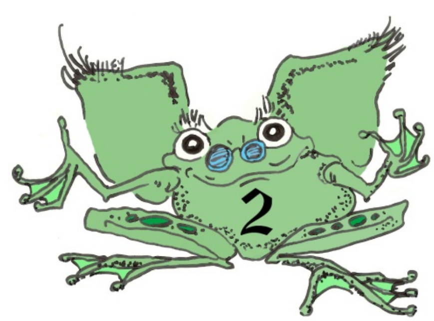
Students should wear goggles.

Safety discussions should focus on safe use of the heat source and the danger of the heated/boiling water.

Remember that classroom thermometers are not very accurate so the water may not boil at a reading of 100ºC.

Day 5

Administer the assessment: *MiSP Phase Changes Assessment*.



Internet Resources:

Periodic table – melting/boiling – solid/liquid/gases at various temperatures
http://www.lon-capa.org/~mmp/period/phase.htm

Phases of matter in containers
http://mutuslab.cs.uwindsor.ca/schurko/animations/phasescontainers/phasescontainer.html

Visualization of water, copper, nitrogen molecular motions
http://www.miamisci.org/af/sln/phases/nitrogengas.html

Solid/liquid/gas visualization
http://www.harcourtschool.com/activity/states_of_matter/index.html

Molecular motions of water with thermometer (no graph)
http://mutuslab.cs.uwindsor.ca/schurko/animations/waterphases/status_water.htm

PHET phase change simulation – molecular motion – uses Kelvin temps
http://phet.colorado.edu/simulations/sims.php?sim=States_of_Matter

Phase change graph / molecular motion / pressure
http://treefrog.fullerton.edu/chem/LS/coolheat.html

PowerPoint on solids, liquids, and gases, phase changes with links to simulations
www.teacherweb.com/CT/EHA/Staires/**phasegraph**final.ppt

Phase change worksheet (high school level)
http://www.galaxynet.com/~corvid/psc/psca_phase_change_worksht.htm