

# CONVECTION

## PROBLEM

Can moving matter carry thermal energy?

## INTRODUCTION

Convection is the transfer of heat by the motion of liquids and gases. Free (or natural) convection occurs whenever there is a temperature difference in a gas or liquid. Free convection in a gas occurs because gas expands when heated. Hot gas with lower density is lighter than surrounding cooler gas and floats upward, carrying heat along with it. Convection in liquids also occurs because of differences in density. Hot liquid is less dense than cold liquid. Therefore, hot liquid rises and cold liquid sinks. The resulting current transfers heat from hotter regions of liquid to cooler regions. In this investigation, you will: observe the currents created by free convection in water; and observe the rapid exchange of thermal energy in forced convection.

## MATERIALS (per group)

Beaker (600 mL); Clear identical glasses (2); Colored ice cube; Hot plate; Stirring rod; Thermometer; Tongs; Uncolored ice cubes.

## PROCEDURE

1. This experiment requires preparation a day ahead of time. Make a colored ice cube by mixing five drops of food coloring in enough water to fill 1 pocket of an ice cube tray. Fill the rest of the tray with clear water and place the tray in the freezer overnight.
2. Using a hotplate, heat about 40 mL of water to about 60°C. Obtain two clear glasses that are the same size and shape. Fill one with the hot water. Fill the other glass with water and a few ice cubes that are not colored. Stir the water and ice well.
3. Remove the colored ice cube from the tray. Using the tongs, dip about 2 centimeters of the colored ice cube into the hot water and observe what happens.
4. Remove the ice cubes from the glass of cold water so they do not interfere with observing. Using the tongs, dip about 2 centimeters of the colored ice cube into the cold water and observe what happens. Remove the colored ice cube and put it back in the freezer.
5. The effect of forced convection can be demonstrated using the colored ice cube. With the ice cube, the color allows you to see the mixing of low and high temperature that would normally be detectable only with sensitive probes. Prepare two glasses with hot water.
6. Using the tongs, dip the colored ice cube into one cup of water and observe the rate at which the colored water mixes with the clear water. The rate at which the liquids mix reflects the rate at which heat is being carried by convection from the water farther from the ice cube to the ice cube itself. Remove the colored ice cube before it melts to half its original size.
7. Have a partner stir the hot water in the other glass. While the water in the glass is still spinning, dip the colored ice cube in the glass with the stirred water (and keep stirring). Observe the rate at which the colored water mixes with the clear water while stirring. Stirring is a form of forced convection because the water is circulated by forces other than natural convection.



**OBSERVATIONS**

Free and Forced Convection	
Convection in:	Description (Direction, Speed)
Cold, unstirred water	
Hot, unstirred water	
Hot, stirred water	

**CONCLUSIONS**

1. Explain the motion of the cold water melting off the colored ice cube when it was partially immersed in hot water using the concepts of density and buoyancy of hot and cold liquids. \_\_\_\_\_  
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2. Was the convection faster or slower in cold water than in hot water? Explain. \_\_\_\_\_  
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3. In which situation would you expect more rapid flow of heat, free convection or forced convection? Why? Does this agree with your observations? \_\_\_\_\_  
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