

### Activity C06: Determine the Vapor Pressure of a Compound (Pressure, Temperature Sensors)

Concept	<i>DataStudio</i>	<i>ScienceWorkshop (Mac)</i>	<i>ScienceWorkshop (Win)</i>
Phase change	C06 Vapor Pressure.DS	C06 Determine Vapor Pressure	C06_VAPO.SWS

Equipment Needed	Qty	Equipment Needed	Qty
<b>Pressure Sensor (CI-6532A)</b>	1	<b>Thermometer (SE-9084)</b>	1
<b>Temperature Sensor (CI-6505A)</b>	1	<b>Tubing, plastic (w/sensor)</b>	1
Beaker, 400 mL	2	Protective gear	PS
<b>Connector, rubber stopper (w/sensor)</b>	1		
<b>Coupling, quick release (w/sensor)</b>	1	<b>Chemicals and Consumables</b>	<b>Qty</b>
Flask, 250 mL	1	Acetone	10 mL
Graduated cylinder	1	Ethanol	10 mL
Hot plate	1	Glycerin	1 mL
Rubber stopper, two-hole	1	Water	1 L

#### What Do You Think?

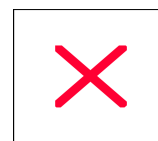
How does the vapor pressure of a pure liquid change as the temperature of the liquid changes? Will the type of liquid have an effect on the rate of change of the vapor pressure as the temperature changes?



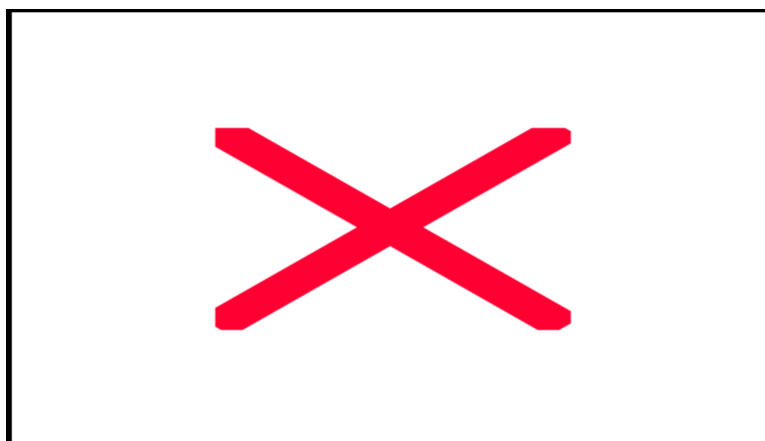
*Take time to answer the 'What Do You Think?' question(s) in the Lab Report section.*

#### Background

Most substances have characteristic melting and boiling points at a given pressure. If the temperature of the surroundings is higher than the temperature of the substance, the surroundings give thermal energy to the molecules of matter that make up the substance. The thermal energy causes the molecules to rotate (spin), vibrate and translate (move from place to place). The intermolecular forces of attraction that hold the molecules of a substance together are strained by an increase in any movement of the molecules. Strong intermolecular forces of attraction are more difficult to break and as a result require a higher temperature to cause molecular movement.



The higher the temperature of a liquid, the greater the average kinetic energy of the molecules. When the molecules of solid matter absorb enough energy, the substance melts and forms a liquid. When liquid matter absorbs enough energy, the molecules move with enough speed and momentum to separate from each other and escape into the vapor or gas phase. As more and more molecules break from



the liquid state into the vapor or gaseous state, the pressure they exert increases in a closed system. This is the vapor pressure of a liquid. The vapor pressure of all liquids is directly related to the temperature of the liquid.

**SAFETY REMINDERS**

- Wear protective gear.
- Follow directions for using the equipment.
- Dispose of all chemicals and solutions properly.

**SAFETY ALERT**

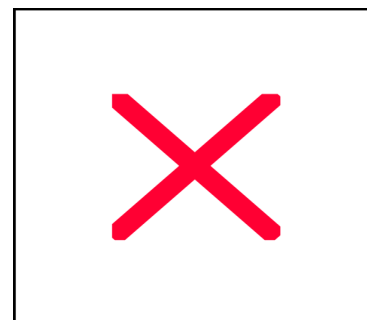
**Keep flammable substances away from flames.**

**For You To Do**

Use the Pressure Sensor to measure the vapor pressure of the liquid inside a flask. Use the Temperature Sensor to measure the temperature of the liquid. Use *DataStudio* or *ScienceWorkshop* to record and display the data.

**PART I: Computer Setup**

1. Connect the *ScienceWorkshop* interface to the computer, turn on the interface, and turn on the computer.
2. Connect the DIN plug of the Temperature Sensor into Analog Channel A of the interface. Connect the DIN plug of the Pressure Sensor into Analog Channel B of the interface.
3. Open the file titled as shown;



<i>DataStudio</i>	<i>ScienceWorkshop (Mac)</i>	<i>ScienceWorkshop (Win)</i>
C06 Vapor Pressure.DS	C06 Determine Vapor Pressure	C06_VAPO.SWS

- The *DataStudio* file has a Workbook display. Read the instructions in the Workbook.
- The *ScienceWorkshop* file has a Graph display with a plot of Temperature versus Time and a plot of Pressure versus Time.
- Data recording is set for ten measurements per second (10 Hz).

## PART II: Sensor Calibration and Equipment Setup

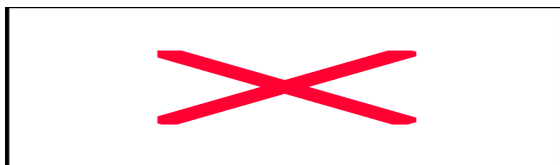
You do not need to calibrate the sensors.

### Set Up Two Water Baths

1. Set up a cool water bath. Half fill one beaker with cool water.
2. Set up a warm water bath. Half fill a second beaker with water and place the beaker on the hot plate. Start heating the second water bath to a temperature of 60 °C. Use the thermometer to check the temperature occasionally as you set up the rest of the equipment.

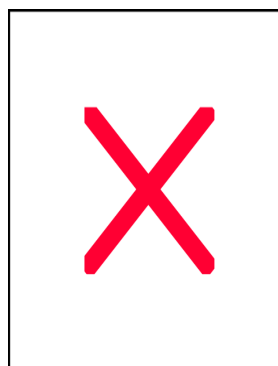
### Set Up the Equipment

1. Put a drop of glycerin on the barb end of the quick-release coupling and insert the barb into one end of the plastic tubing.
2. Put a drop of glycerin on the smaller diameter end of the coupling that will go into the



rubber stopper. Insert the small diameter end into the plastic tubing.

3. Put a drop of glycerin on the larger diameter end of the connector that will go into the rubber stopper, and insert the end into one of the holes in the rubber stopper.
4. Place a drop of glycerin in the other hole of the rubber stopper. Slide the Temperature Sensor through the hole in the rubber stopper.

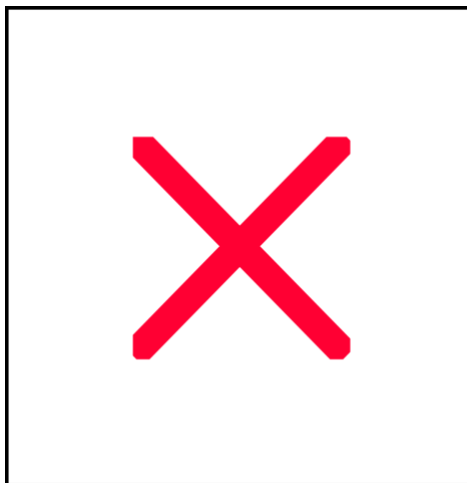


**NOTE:** Do not put the rubber stopper into the flask yet.

5. Put 10 mL of acetone in the flask. Hold the flask in the hot water bath.
6. Leave the flask in the water bath for four minutes to allow the acetone to vaporize and purge air from the flask.

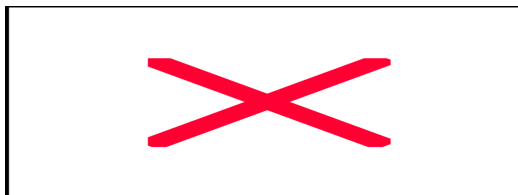
**PART IIIA: Data Recording - Acetone**

1. Place the two hole stopper firmly into the top of the flask with the acetone. Adjust the




Temperature Sensor in the rubber stopper so the tip of the sensor is in the liquid.

2. Align the quick-release connector on the end of the plastic tubing with the connector on the pressure port of the Pressure Sensor. Push the connector onto the port, and then turn the connector clockwise until it clicks (about one-eighth turn).



3. Remove the flask from the water bath.

4. Start recording data. (Hint: In *DataStudio*, click 'Start' (). In *ScienceWorkshop*, click 'REC' (.

5. Observe the change in temperature and pressure as the flask cools.

**What do you expect the temperature vs. time and the pressure vs. time graphs will look like?**

6. After four minutes immerse the flask in the cool water bath.
7. Continue recording data until the temperature reaches about 30 °C. (Hint: Click 'Stop' to end the data recording.)
8. Slowly remove the two hole stopper to allow air to enter the flask.
9. Dispose of the remaining acetone by rinsing the acetone down the drain with a large volume of water following. Rinse and dry the flask.

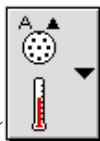
### PART IIIB: Data Recording - Ethanol

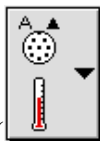
1. Heat the hot water bath to 75 °C.
2. Put 10 mL of ethanol in the flask. Hold the flask in the hot water bath.
3. Leave the flask in the water bath for four minutes to allow the ethanol to vaporize and purge air from the flask.
4. Place the two hole stopper firmly into the top of the flask with the ethanol. Adjust the Temperature Sensor in the rubber stopper so the tip of the sensor is in the liquid.
5. Repeat the data recording procedure for the ethanol.

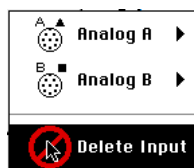
How will the graphs for ethanol differ from the graphs for acetone?


### Analyzing the Data

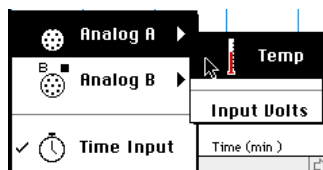
1. Set up your Graph display to show the data for acetone and for ethanol.
  - (Hint: Rescale the Graph to the data if necessary.)
2. Use the Graph display to determine the relationship between pressure and temperature for the two liquids.
  - (Hint: In *ScienceWorkshop*, change the Graph display to show Pressure on the vertical axis versus Temperature on the horizontal axis.



- Click on the “Input” menu button (  ) for the vertical axis of the temperature plot of the Graph.
- Select “Delete Input” from the Input menu for the temperature plot.




- Click on the “Input” menu button (  ) for the horizontal axis of the Graph.
- Select “Analog A, Temp” from the Input menu for the horizontal axis.



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- (Click on the “Autoscale” button () to rescale the Graph to the data if necessary.)

Use your observations to help you answer the questions in the Lab Report section.

## Lab Report - Activity C06: Determine the Vapor Pressure of a Compound

### What Do You Think?

How does the vapor pressure of a pure liquid change as the temperature of the liquid changes?  
Will the type of liquid have an effect on the rate of change of the vapor pressure as the temperature changes?

### Questions

1. What is the general relationship between the vapor pressure of acetone and the temperature of the liquid?
2. Is the relationship linear? Why or why not?
3. What is the general relationship between the vapor pressure of ethanol and the temperature of the liquid?
4. Is the relationship between acetone and temperature and ethanol and temperature the same? How are they different?
5. Which would you predict has the higher boiling point, acetone or ethanol? Clearly state your reasons.
6. From the results of your experiment which liquid, acetone or ethanol, has the stronger intermolecular forces of attraction. Clearly state your reasons.



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7. Using what you learned in this experiment, sketch the pressure vs. temperature for methanol, water, and methane.