

ASHES TO ASHES: USING EVAPORATION RATE TO IDENTIFY AN UNKNOWN LIQUID

LAB FORENSICS.11

From Texas Instruments, *TI Classroom Activities*, 2006



Case File 11

Measure and compare the cooling rates of unknown liquids, and identify the probable arsonist.

PROBABLE ARSON

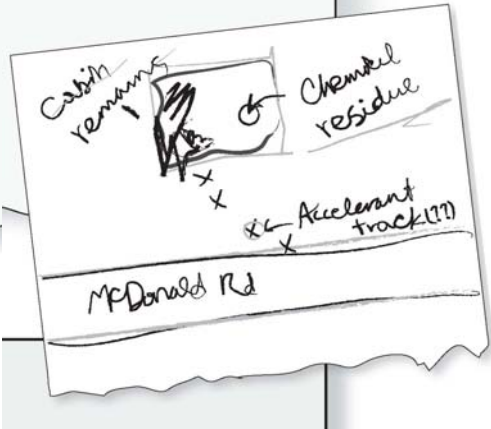
Investigator: James
Date: 10/05/05

- call in at 3:04 a.m.
- large fire on the East Side; historic log cabin of town founder, James McDonald
- first responders too late to save cabin
- traces of an unidentified chemical residue discovered in cabin remains
- drops of unidentified chemical found between cabin remains and main road

(?accelerant used to spread the fire?)

ARSON strongly suspected

- chemical evidence sent to lab for testing



A hand-drawn sketch of the crime scene. It shows a rectangular area representing the cabin remains, with a large 'X' inside. To the right of the cabin is a circle labeled 'Chemical residue'. Below the cabin is a horizontal line labeled 'McDonald Rd'. An arrow points from the cabin towards the road, with the text 'Accelerant track(?)' written next to it. There are small 'x' marks along the path from the cabin to the road.

McDonald Cabin Arson Suspect List

The following four people were found within three blocks of the blaze in the early morning and were brought in for questioning. Each has access to flame accelerants for one reason or another. Chemicals collected from each of the suspects have been sent to the lab for identification and comparison with those collected at the scene.

Suspect 1: Barney Weber: member of school custodial staff

Weber was found cleaning out the back of his truck several blocks from the crime scene.

Suspect 2: Anna Appleby: local painter and muralist

Police found Appleby finishing a mural on a warehouse wall across the street from the fire.

Suspect 3: Virginia Lawson Smith: mechanic

Lawson Smith called the fire department. Police questioning her found chemicals on her work clothes.

Suspect 4: Dr. Martin Brown: university chemist

Brown was transporting a cart of chemicals to his college laboratory when police picked him up.



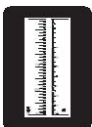
Forensics Objective

- identify the likely accelerant in an arson



Science and Mathematics Objectives

- identify a solution, based on evaporation rate
- understand that evaporation rate is a characteristic property of a liquid



Materials (for each group)

- TI-83/TI-84 Plus™ Family
- Vernier EasyTemp™ temperature probe
- Vernier EasyData™ application
- accelerant samples from 4 suspects
- accelerant sample from crime scene
- 5 small test tubes
- test-tube rack
- 6 pieces of filter paper cut into 2×2 cm squares
- 6 small rubber bands
- lint-free tissues or paper towels
- goggles (1 pair per student)



Procedure

In order to determine whether any of the accelerants found with the suspects matched the accelerant found at the crime scene, you will need to compare the evaporation rate of each suspect's sample with the evaporation rate of the sample from the crime scene. You will compare the samples by, first, graphing the temperature change of each sample as it evaporates and, second, comparing the graphs of each sample to look for a match. Because your calculator can display only three curves at a time on a graph, you will need to create two different graphs with three curves (two suspect samples and the crime scene sample) on each graph.

1. Connect the EasyTemp temperature probe to the USB port on your calculator.
2. To set up the EasyData App for data collection, select **File** from the Main screen, and then select **New** to reset the application. The Main screen should be displayed. You should see the current temperature reading at the top of the screen and **Mode: Time Graph: 180 (s)** near the bottom of the screen.



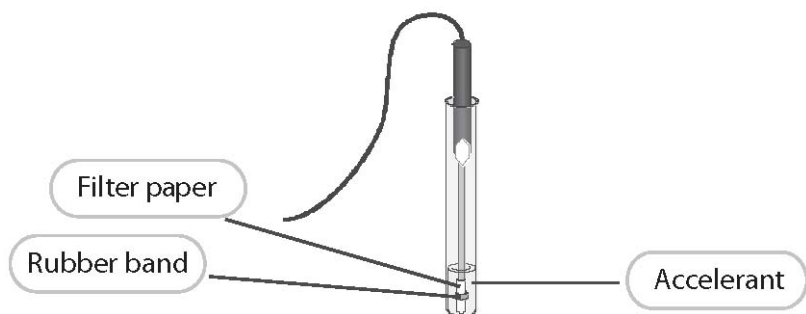
At the bottom of the Main screen are five options (**File**, **Setup**, **Start**, **Graph**, and **Quit**). Each of these options can be selected by pressing the calculator key located below it (**Y=**, **WINDOW**, **ZOOM**, **TRACE**, or **GRAPH**).

3. The default experimental setup is to collect one sample every second for 180 seconds. For this experiment, you will need to collect one sample every second for 240 seconds. Change the length of the experiment to 240 seconds.
 - a) Select **Setup** from the Main screen.
 - b) Select **2: Time Graph**.
 - c) Select **Edit** to change the values. The default sample interval is 1 second, which is what we want for this experiment. Select [Next] to move to the next option.
 - d) Press **CLEAR** to remove the default number of samples (180), and type **240** as the number of samples.
 - e) Select **Next**.
 - f) Confirm that the settings are correct (sample interval = 1 second, number of samples 240, experiment length = 240 seconds) and then select **OK**.



Obtain and wear goggles! CAUTION: The compounds used in this experiment are flammable and poisonous. Avoid inhaling their vapors. Avoid touching them with your skin or clothing. Be sure there are no open flames, heat sources, or sparks in the lab during this experiment. Notify your teacher immediately if an accident occurs.



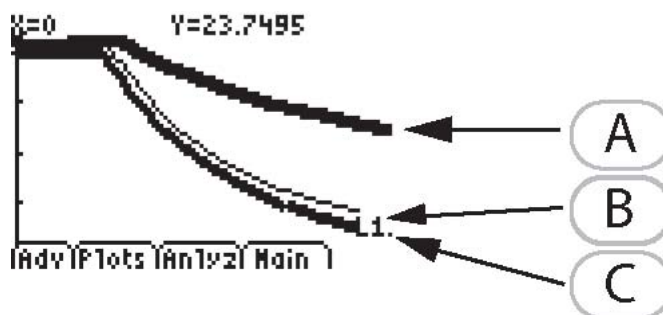
4. Wrap the probe with a square of filter paper, and secure the paper with a small rubber band, as shown in the figure.



5. Pour a small amount of the accelerant from Suspect 1 into a test tube. Place the test tube in a test-tube rack, and place the temperature probe into the test tube so that the filter paper is covered by the liquid.
6. After the probe has been in the liquid for at least 30 seconds, select **(Start)** to begin collecting temperature data. On the calculator screen, a real-time graph of temperature vs. time will be displayed. The temperature readings are displayed in the upper right corner of the graph.
 - a) Leave the temperature probe in the test tube for 15 seconds to establish the initial temperature of the liquid.
 - b) Remove the probe from the liquid, and tape it to the table so the tip of the probe extends over the edge of the tabletop.
7. Data collection will stop after 240 seconds. The graph of temperature vs. time will then be scaled and displayed. The time, **X**, and temperature, **Y**, values are displayed above the graph.
 - a) Use the arrow keys to move along the graph and determine the maximum and minimum temperatures for this sample. Record the maximum temperature as the T_{\max} in your Evidence Record, and record the minimum temperature as T_{\min} .
 - b) Subtract the minimum temperature from the maximum temperature to determine the temperature change during evaporation. Record this value in the Evidence Record.
8. To store the data that you collected during this run, select **(Main)** to return to the Main screen. Select **(File)** and choose option **5: Store Run...** If you get a message about overwriting stored data, select **(OK)**.
9. Remove the rubberband, dispose of the filter, and dry the probe thoroughly.
10. Repeat steps 4–9 with the accelerant from Suspect 2.

11. With the accelerant from the crime scene, repeat steps 4–7 *only*. (*Careful! Do not store this run, or your data will be overwritten.*)
12. Plot the data from all three accelerants on the same graph.
 - a) Select **Adv**.
 - b) Select **7VL2, L3 and L4 vs L1**.
13. Compare the graphs to decide whether either Suspect 1 or Suspect 2 had an accelerant that is likely to be the same as the accelerant used at the crime scene.
 - a) If one of the suspects' accelerants produces a plot that matches the shape of the plot from the crime scene accelerant, it could be the accelerant that was used.
 - b) To identify which plot corresponds to which accelerant, use  and  to move the cursor from plot to plot and match the T_{\max} and T_{\min} values to those in your Evidence Record.

See the example.



You can see that curves B and C are nearly identical in shape. Curve B is from the crime scene. Accelerant C is most likely to have been the accelerant used at the crime scene.

14. Even if you got a match in step 13, you need to test and compare the other two accelerants; two of the accelerants could be the same. Select **Main** to return to the Main screen. Repeat steps 4–13 for the accelerants from Suspect 3 and Suspect 4 and the accelerant from the crime scene. (Remember, *do not* perform a Store As for the crime scene run.)



NAME: _____

DATE: _____

Evidence Record

Substance	T _{max} (°C)	T _{min} (°C)	T _{max} - T _{min} (°C)	Cooling-Rate Graph Match?
Suspect 1				
Suspect 2				
Suspect 3				
Suspect 4				
Crime Scene				NA

Case Analysis

1. Which of the suspects' accelerants best matches the accelerant from the crime scene?
2. Did any of the suspects' accelerants appear to be the same liquid? If so, which ones?
3. Why may the graphs of the crime scene accelerant and primary suspect's accelerant not match exactly?
4. In what other ways can you examine the accelerants to determine which one was used in the crime?

