

Boil, Boil, Toil and Trouble

The International Boiling Point Project

Student Pre-project Assessment

Read the Following

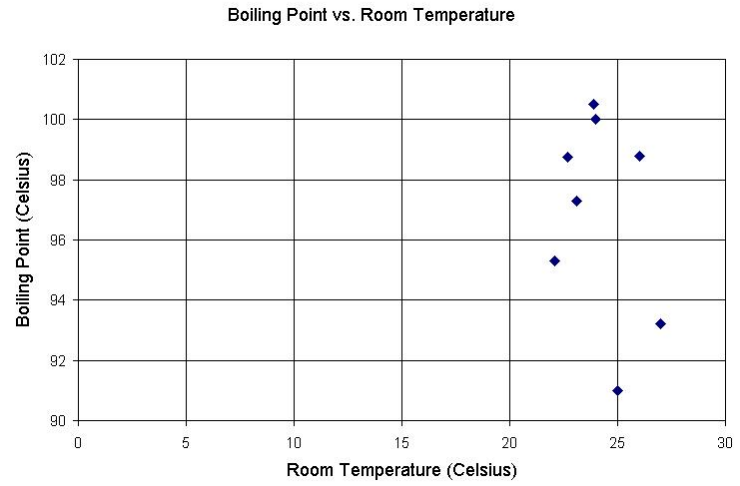
One day in your science class you find a dusty old lab notebook in the bottom of a drawer. Curious, you open it up and see what looks like data that a previous student had collected. You show it to your teacher and she says she will give you extra credit if you can figure out what it all means. This is what is in the notebook:

Boiling Point of Water

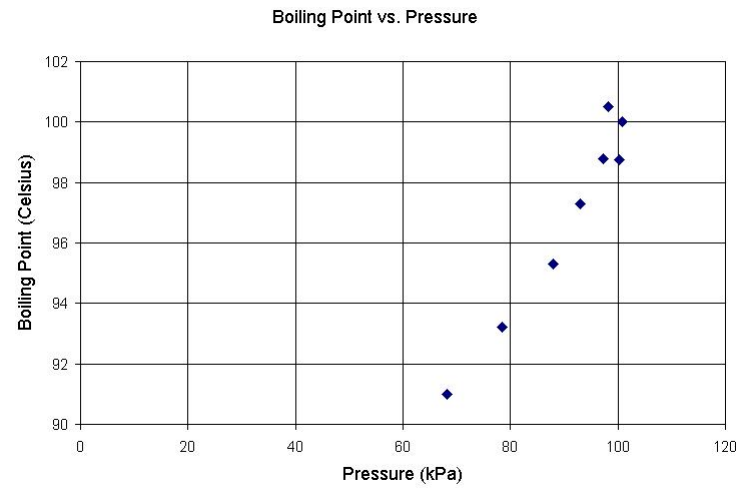
Location	Type of Thermometer	Avg. Room Temp. (C)	Pressure (kPa)	Avg. Boiling Point (C)
Hoboken, New Jersey	Glass	24	100.9	100
Hebron, Kentucky	Electronic probe	23.9	98.2	100.5
Etna, Maine	Glass	22.67	100.3	98.75
Bucklin, Kansas	Electronic probe	23.1	93	97.3
Aspen, Colorado	Plastic	25	68.2	91
Phoenix, Arizona	Glass	26	97.3	98.8
Anza, California	Plastic	22.1	87.9	95.3
Laramie, Wyoming	Glass	27	78.4	93.2

After staring at the data for a while, you still can't figure out if there is any relationship among all the data. You decide to make some graphs of the data which are shown on the next page.

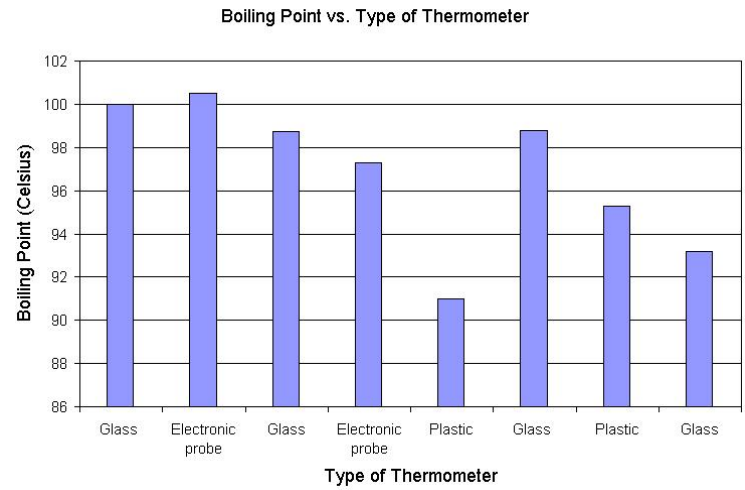
Graph A



Graph B



Graph C



Questions

1. Examine each of the graphs on the previous page.

a) Which graph shows the strongest relationship to the boiling point of water?

b) For the graph you selected in part (a) sketch a trend line or line of best fit on the graph.

c) For the graph you selected in part (a), describe the trend you see.

d) Using data from the graph you selected in part (a), give an example that clearly describes the trend shown in the graph.

2. One of your classmates says that the boiling point of water depends on elevation. Do you agree with her? Explain why or why not.

3. The page in the old notebook with the data table is torn and you can't read one entry at the bottom. This is what it looks like:

Location	Type of Thermometer	Avg. Room Temp (C)	Pressure (kPa)	Avg. Boiling Point (C)
Mexico City, Mexico	Electronic Probe	24	90	

Using one of the graphs on the previous page, predict what the boiling point of water should be for this entry. Explain how you arrived at this answer.

Pre-project Assessment Answer Key and Grading Rubric

TOTAL POSSIBLE POINTS: 10

1. Examine each of the graphs on the previous page.

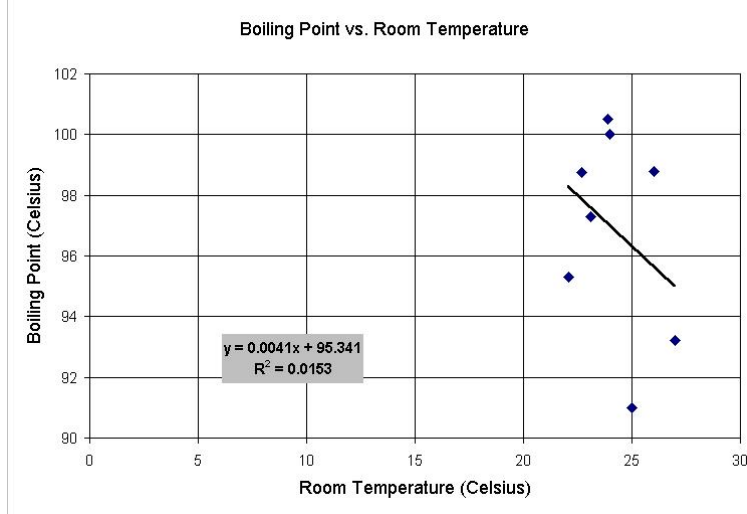
a) Which graph shows the strongest relationship to the boiling point of water?

Part (a) Answer: Graph B, Boiling Point vs. Pressure shows the strongest relationship to boiling point.	
Points	Acceptable Response
1	Correctly states that graph B shows the strongest relationship to boiling point.
Points	Unacceptable Responses
0	States that either graph A or C shows the strongest relationship to boiling point. Any other response.

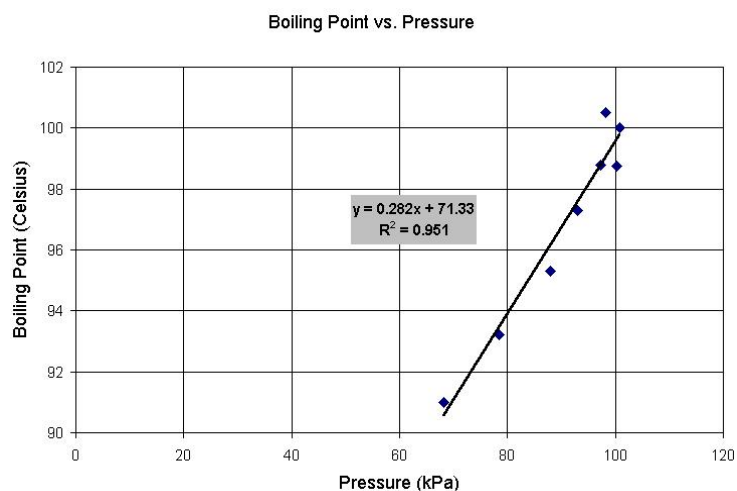
b) For the graph you selected in part (a) sketch a trend line or line of best fit on the graph.

Part (b) Answer: For either graph A or B, students should draw a straight line that represents the trend in data. Approximately half the points should be above the line and half the points below it. They should not "connect the dots." It is not possible to draw a trend line for graph C.

If students select graph A, the trend line should look something like the line shown below.



If Students select graph B, the trend line should look something like the line shown below. Graph B shows the most distinct trend in data.



It is not possible to draw a trend line for graph C, and if students select this graph, they should indicate this in their answer.

Points	Acceptable Responses
2	Correctly indicates the trend line on the graph they selected. The line should be straight with half the points above the line and half below it. It should indicate the general trend in the data. If a student selects graph C, they should indicate that it is not possible to draw a trend line for a bar graph.
Points	Partial Credit Responses
1	Has the general idea of how to draw a trend line or line of best fit but either it is not straight or points are not equally distributed above and below the line.
Points	Unacceptable Responses
0	Does not draw the trend line correctly. Attempts to draw a trend line for Graph C.

c) For the graph you selected in part (a), describe the trend you see.

Part (c) Answer: Looking at the Boiling Point vs. Pressure graph, one can see that as pressure increases, the boiling point increases (or vice-versa).	
Note: There are no clear trends for the other graphs.	
Points	Acceptable Responses
1	States that as pressure increases, boiling point increases (or that boiling point decreases as pressure decreases).
Points	Unacceptable Responses
0	Any other response.

d) Using data from the graph you selected in part (a), give an example that clearly describes the trend shown in the graph:

Part (d) Answer: Looking at the Boiling Point vs. Pressure graph and the data recorded in the notebook, one can see that as the pressure increases from 78.4 to 93 kPa, the boiling point increases from 93.2°C to 97.3°C.	
Note: There are no clear examples for the other graphs.	
Points	Acceptable Responses
1	Refers to a specific example that correctly illustrates the trend. OK if student provides estimated numbers from graph instead of exact numbers from notebook as long as trend is correct.
Points	Unacceptable Responses
0	Gives an example that does not correctly illustrate the trend in data or provides no example.

2. One of your classmates says that the boiling point of water depends on elevation. Do you agree with her? Explain why or why not.

Answer: Yes, the boiling point of water does depend on elevation. Atmospheric pressure usually varies with elevation. The higher the elevation, the lower the atmospheric pressure (and vice-versa). One would expect to see a lower boiling point at higher elevations where the atmospheric pressure is lower.

Optional (higher level response): The less atmospheric pressure that bears down on the surface of the liquid, the easier it is for water molecules to escape into the air. Thus, the water comes to its full rapid boil at a lower temperature in the mile-high city of Denver than it can at sea level in Miami.

Points	Acceptable Responses
2	Correctly states that the boiling point depends on elevation. Understands that atmospheric pressure is related to elevation or altitude.
Points	Partial Credit Responses
1	Correctly states that boiling point depends on elevation but does not provide any further explanation or provides an incorrect explanation.
Points	Unacceptable Responses
0	Does not understand that atmospheric pressure is related to elevation.

3. The page in the old notebook with the data table is torn and you can't read one entry at the bottom. Using one of the graphs on the previous page, predict what the boiling point of water should be for this entry. Explain how you arrived at this answer.

Answer: Graph B should be used because boiling point is most dependent on pressure. At 90 kPa, the boiling point should be approximately 97° C. If students sketch in a trend line, they should look for 90 kPa on the x-axis (halfway between 80 and 100 kPa), then follow this point up until they hit the trend line. From this point, they would move horizontally to the left until they see where this falls on the y-axis. If students do not draw in a trend line, they can still estimate the boiling point. Any estimate between 95°C and 97°C would be acceptable.

Points	Acceptable Responses
3	Uses the pressure graph to find the boiling point of water. Estimates the boiling point to be somewhere between 95°C and 97°C. Explains how the boiling point was determined.
Points	Partial Credit Responses
2	Uses the pressure graph to find the boiling point of water and obtains an acceptable answer but does not explain how the answer was obtained. Or uses the correct graph and gives a satisfactory explanation but gives an unacceptable boiling point.
1	Uses the correct graph but does not obtain an acceptable answer nor explain how the answer was obtained.
Points	Unacceptable Responses
0	Does not use the correct graph or give an acceptable answer. Provides no explanation for how answer was obtained.