

# Boiling Point of Water

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### Question:

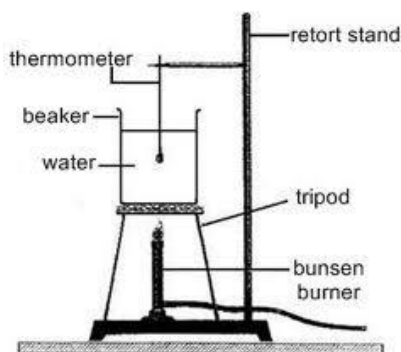
What is the boiling point of water?

### Hypothesis:

The kinetic theory that states that all molecules are in a constant state of motion and increasing the temperature of the system will result in an increase in their motion. When the attractive forces between molecules are overcome and a phase change occurs from a liquid to a vapor, the boiling point will have been reached. Based on this knowledge, it is expected that the boiling point of water will be 100.0 degrees Celsius.

**Comment [Vs1]:** Hypothesis based on background research and prior knowledge.

### Materials:



- Bunsen burner
- Retort stand
- Tripod
- 400 mL Beaker
- Thermometer
- Tongs

**Comment [Vs2]:** All materials listed; includes diagram of equipment set-up

### Procedure:

1. Pour 250 mL of distilled water at room temperature into 400 mL beaker.
2. Place thermometer in beaker and record initial temperature.
3. Place beaker onto tripod. Light Bunsen burner.
4. Record water temperature every 2 minutes until water boils vigorously and the same temperature is recorded for 2 observations.
5. Turn Bunsen burner off and use tongs to carefully remove beaker.
6. Repeat steps 1 – 5 twice.

**Comment [Vs3]:** Procedure listed in a step-wise fashion; includes details like units of measurement, type of water to be used, when to end timing, and safety measures for transfer of beaker.

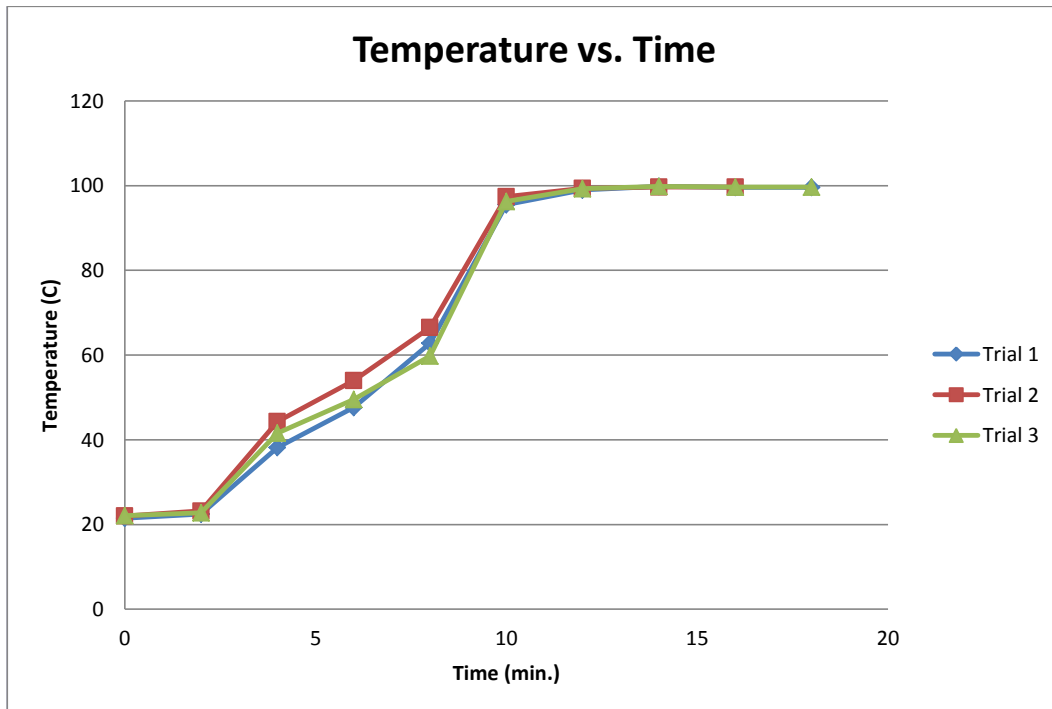
## Results:

Table: Heating Water

| Time (min) | Temperature (°C) |         |         |
|------------|------------------|---------|---------|
|            | Trial 1          | Trial 2 | Trial 3 |
| 0          | 21.5             | 22.0    | 22.1    |
| 2          | 22.5             | 23.2    | 22.8    |
| 4          | 38.2             | 44.3    | 41.6    |
| 6          | 47.6             | 54.0    | 49.5    |
| 8          | 62.8             | 66.5    | 59.8    |
| 10         | 95.5             | 97.4    | 96.3    |
| 12         | 99.0             | 99.4    | 99.3    |
| 14         | 99.8             | 99.7    | 99.8    |
| 16         | 99.6             | 99.7    | 99.7    |
| 18         | 99.6             |         | 99.7    |

**Comment [Vs4]:** Table has title; includes units of measure; measurements in correct significant digits; table properly formatted.

Graph: Temperature vs. Time



**Comment [Vs5]:** Graph includes main title and axes titles; includes legend; axes titles include units of measure

## Observations:

- Small bubbles could be seen at the bottom of the beaker just prior to boiling.
- Rapid bubbling was accompanied by steam.

**Comment [Vs6]:** Observations are detailed and related to experimental results.

## Discussion:

Water can be found in three states; solid (ice), liquid, or gas (steam). Intermolecular forces like London and dipole-dipole forces hold water molecules together in either the solid or liquid state. The boiling point of water is reached when it changes phase from a liquid to a gas. For water to undergo a phase change, these intermolecular forces must be overcome by an input of energy. According to the kinetic theory, molecules are in constant motion. As energy is added, the kinetic energy of the molecules increases and, in turn, molecular motion increases. The resulting collisions between molecules eventually weaken the bonds between water molecules. The particles separate and move about independently as a gas. The average kinetic energy of the molecules can be measured by taking the temperature of the water as heat energy is added. The temperature at which water undergoes a phase change is the boiling point of water.

**Comment [Vs7]:** Provides a well-written, detailed description of the basic science involved in the experiment. Includes how the measurement of temperature is used to determine phase change/boiling of water.

The average temperature at which water underwent a phase change and boiled was found to be 99.7 degrees Celsius. The hypothesis that the water would boil at 100 degrees Celsius can be accepted based on the results of this experiment. The Temperature vs. Time graph shows that in the first few minutes, the temperature increase was minimal but there was a fairly sharp increase in temperature between 3 and 5 minutes. This would correspond to an increase in molecular movement. There was a gradual increase in temperatures over the next few minutes. Another sharp increase in temperature is evident from approximately 8 to 10 minutes into the experiment. This would correspond with the weakening of intermolecular forces between water molecules and the lessening of surface tension as particles break apart and move independently. After this time, the temperature increase of the water slows and eventually remains constant. The temperature does not increase further because the water molecules underwent a phase change in to a gaseous state (i.e. steam). In Trial 2, the temperature increase occurred at a noticeably but not significantly faster rate than in the other two trials.

**Comment [Vs8]:** Provides well-written, detailed summary of overall and specific results; hypothesis accepted based on results; discussion refers to graph and describes patterns/trends in data; relates results to basic science involved in experiment

Increased accuracy of the boiling point temperature may be possible by ensuring that the water is free from added minerals and impurities by using distilled water. Impurities in the water can either increase or decrease the boiling point of water. Additionally, reliance on a more accurate thermometer and heating equipment that can maintain a more consistent input of heat energy would also improve the overall results.

**Comment [Vs9]:** Well-written, detailed error analysis that includes improvements to test and/or equipment. Discussion section written in 3<sup>rd</sup> person/ past tense.

## Conclusion:

The common held theory that water will undergo a phase change from a liquid to a gas at 100 degrees Celsius is supported by the results of this experiment. Further tests could be done to determine the most efficient methods for bringing water to its boiling point using a variety of heating devices.

**Comment [Vs10]:** Nice, well-written overall statement of results; includes idea for further testing. Conclusion written in 3<sup>rd</sup> person/ past tense.