ScienceCube

Volume Change of Gas According to Temperature (Charles's Law)

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1. Observing the volume change of gas with temperature and explaining the relationship.

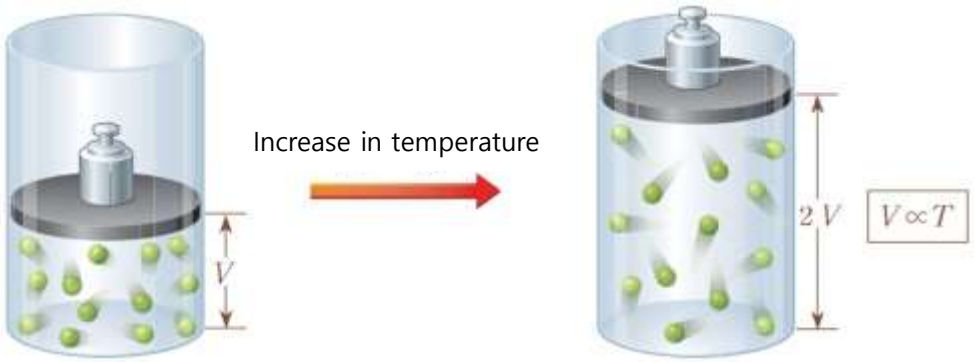
2. Predicting the temperature at which the volume of gas becomes zero and comparing it with the theoretical value.

Fundamental Concept

1. Molecular Motion of Gas and Temperature

1) When the temperature increases: Gas molecules move faster → frequency of collisions between gas molecules increases → volume of gas increases.

2) When the temperature decreases: Gas molecules move slower → frequency of collisions between gas molecules decreases → volume of gas decreases.



2. Relationship between Gas Temperature and Volume

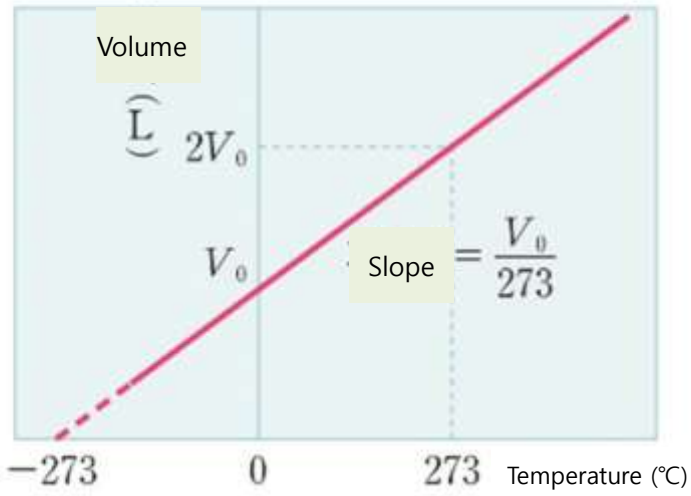
At constant pressure, the volume of any gas increases as the temperature increases: Charles's Law.

3. Charles's Law

(1) Charles's Law

At constant pressure, the volume (V) of a given amount of gas is directly proportional to its absolute temperature (T).

$V=kT$ (k: Proportional constant)

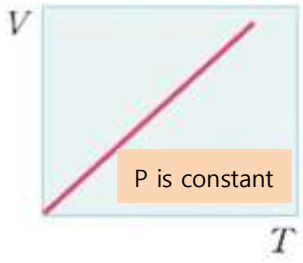
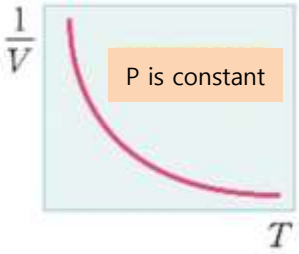
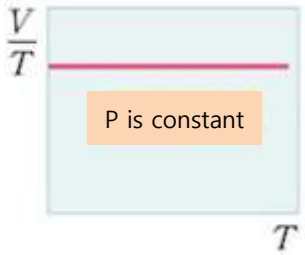


At constant pressure, the volume of a given amount of gas increases by 1/273 of its volume at 0℃ for every 1℃ rise in temperature, and decreases by 1/273 for every 1℃ fall in temperature.

$$V_t = V_0 + V_0 \times \frac{t}{273}$$
$$= V_0\left(1 + \frac{t}{273}\right)$$

(2) Charles's Law and Graphs

Represents the relationship between the volume (V) of gas and temperature (T) at constant pressure.

At constant pressure, the volume of a given amount of gas is directly proportional to its absolute temperature.	Since the volume of a gas is proportional to its absolute temperature, 1/volume of the gas is inversely proportional to the absolute temperature.	Since the volume of a gas is proportional to its absolute temperature, the value of V/T is constant regardless of the absolute temperature.
		

4. **Examples of Charles's Law**

   A dented ping-pong ball can be restored by placing it in hot water.

   Heating the air inside a hot air balloon causes the balloon to rise as the air expands.

   An empty plastic bottle will dent if placed in a refrigerator.

Experiment

Materials Needed

Interface, Science# program (smart device), Volume sensor, Temperature sensor, Water tank, Hot water (from a kettle), Stand

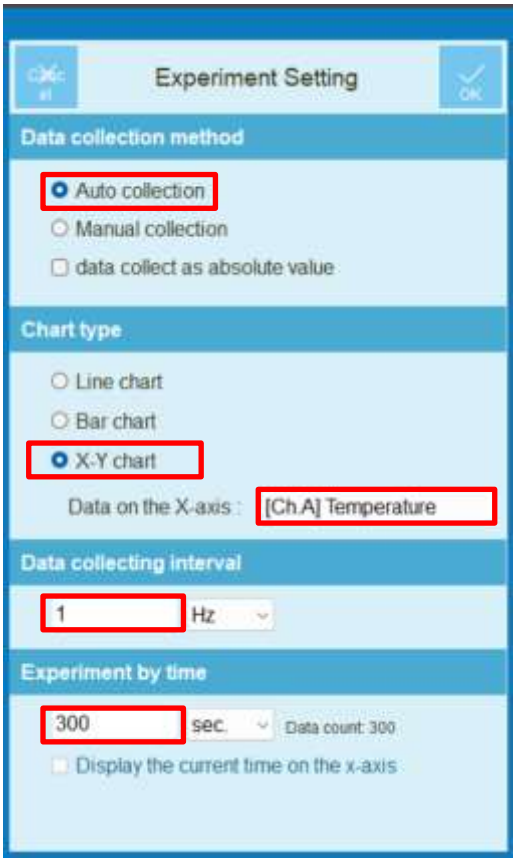
Experimental Setup

1. Install a clamp on the stand as shown below and fix the volume sensor with the clamp.
2. Insert the temperature sensor into the tube hole, ensuring it is sealed to prevent air leakage. (Hold the hole entrance with one hand and gently insert the temperature sensor with the other hand to avoid affecting the volume of the tube.)
3. Heat water to about 50-60℃ and fill the water tank. (Be careful not to use excessively hot water as it may deform the tube.)

4. Place the stand next to the water tank and adjust the height to ensure the volume sensor does not touch the water. (Ensure the ring at the tube entrance is fixed in one direction, either up or down.)

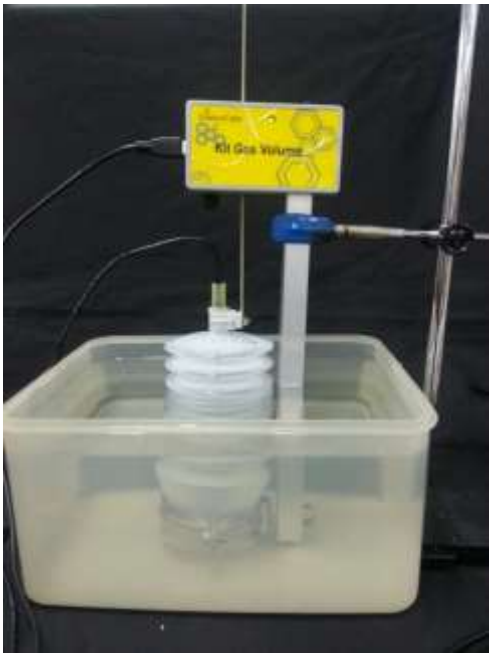
Interface Setup

1. Run Science#.
2. Connect the volume sensor and temperature sensor to the interface.
3. Ensure the yellow lamp on the volume sensor is lit. (If not, compress and expand the tube repeatedly.)
4. Press the button to set up the experimental environment as shown below.



Data Collection

1. Adjust the clamp height so the gas volume is submerged in the water tank, ensuring the tube does not touch the bottom.
2. Quickly press the button  to start data collection.
3. If there is no volume change, press the button  to end the experiment.



Data Analysis

Recording Data

1. Display the volume change according to temperature in a graph.

2. Explain the relationship between temperature and volume based on the experiment results.

   (After data collection, use the <Analysis> tool to fit a linear equation f(x)=Ax+B and display it as a straight-line graph.)

Data Application and Extended Activities

1. Record the temperature at which the volume is 0 mL based on the experiment results.

   (Extend the line from the fitted graph f(x)=Ax+B to find the temperature (x value) when the

volume is 0 (y=0)).

2. Does the temperature at which the volume is 0 mL obtained from the experiment match the theoretical value according to Charles's Law? If not, analyze and explain the reason.