How Does it Work—Geyser Investigative Activity—walk through

Earth Science Essentials

by Russ Colson

My walk-through of the lab is below.

Materials: You will need the balloon and syringe (without the needle) as well as a can of coke from the store.

And brain. Don't forget the brain.

Thinking about how a volcano erupts:

The process for geyser eruption is different from a volcanic eruption. To think about a volcanic eruption take a warm can of magma simulant (which, amazingly, is readily available in most grocery stores—often labeled as "Coca-cola", "Pepsi" or some other secret code). With a hefty safety pin, poke a hole in the small metal dot in the center of the top of the can. Put your finger over the hole and shake vigorously. Set the can on the ground (better to do this outdoors if possible...), and watch the eruption!

There are several ways that this is like a volcanic eruption. In your own words, explain what is causing the eruption of pop from the can, and how this model is like a volcanic eruption (and how it is different).

Shaking the coke can causes the carbon dioxide gas to exsolve (bubble out) of the liquid. This produces a pressurized froth inside the can, which is kind of like a magma chamber. When you take your finger off the hole in the top, the pressurized froth expands into the gap, producing an eruption.

This is like a volcano in that gases in a volcano also exsolve from the magma. When a crack forms from the magma chamber to the surface, the pressurized gases expand into the gap, or propel the liquid into the gap, producing an eruption.

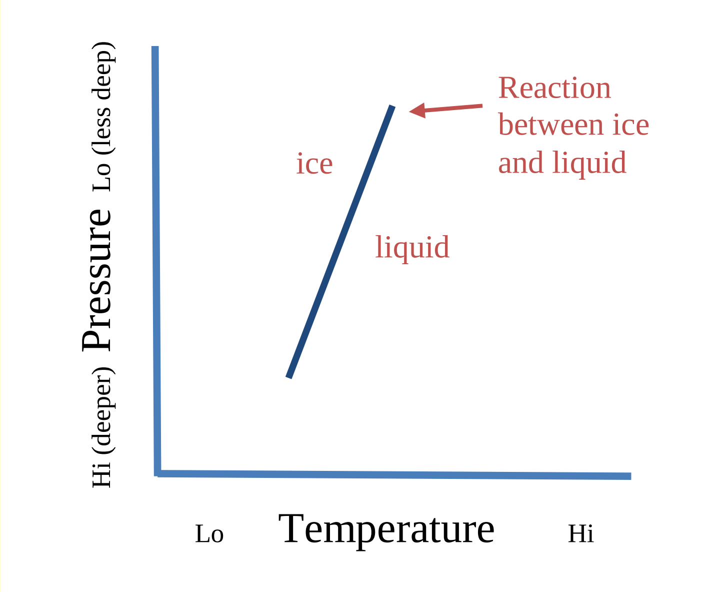
In a volcano, more of the gas is usually water vapor instead of carbon dioxide (although there is some carbon dioxide). Also, the gas does not exsolve due to shaking—rather it exsolves because the pressure decreases as the magma rises from deeper in the crust (more gas dissolves in the liquid when it's under pressure) and because of crystals growing from the melt (the gases are incompatible in the crystals, and so get concentrated in the melt until the melt can't hold them anymore and they exsolve).

Also, magma in a volcano is made of molten silicate, not molten water. And it is much hotter!

Getting the basic idea for Geyser eruptions:

Understanding how a geyser erupts requires that we understand a phase diagram. A phase diagram is a kind of graph that plots conditions under which different occur (as we talked about in the lesson on metamorphic rocks). For a geyser, the key phases are the liquid and gas phases of water. Lines on a phase diagram correspond to chemical reactions—in the case of a geyser, the reaction is between liquid and gaseous water. Along the line, both phases coexist (e.g. liquid and gaseous water). Off the line, only one of the phases exist.

For example, a phase diagram showing the reaction between liquid and solid water looks like the diagram below. Both pressure and temperature affect the reaction between liquid and solid. In general, liquid water forms as we increase temperature at a particular pressure, or increase pressure at a particular temperature. If you remember from our unit on metamorphic rocks, this is because the liquid water is more dense and has higher entropy than the solid.

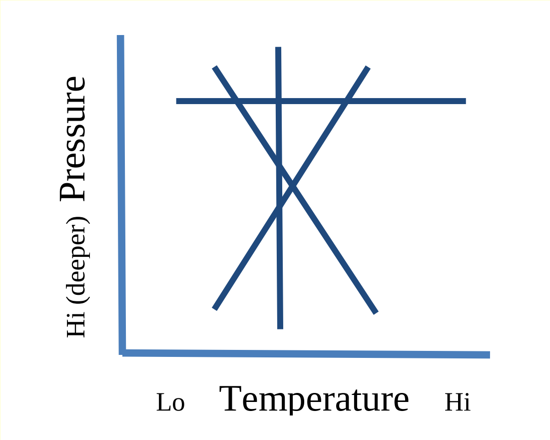


You may have been told that water boils at 100°C. But is this always true? Certainly recipes tell you to boil things longer at high elevation—why boil it longer if the temperature is the same?

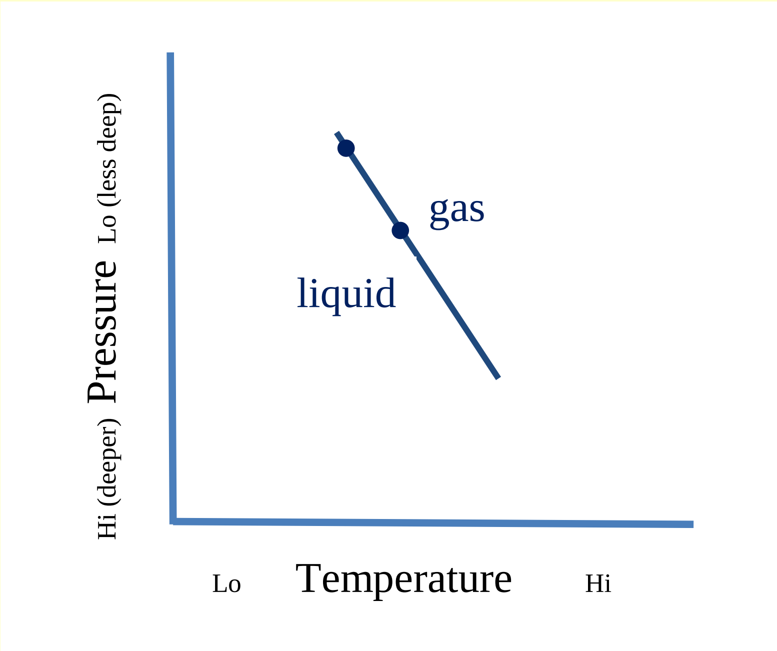
To draw the phase diagram for water, we need to understand how the boiling temperature for water (the line) changes with pressure.

You are going to complete the phase diagram for liquid-gas water. You need to decide how the line on the diagram will trend choosing from one of the options below. Whichever trend you choose, you also need to figure out which side of the line will have 'liquid' on it and which side will have 'gas'.

Four options for trends:



Draw your phase diagram on the graph below.



Water at 1-atm pressure (average pressure at sea level) boils at 100°C. The temperature of my syringe experiment was room temperature—about 21°C.

The water started to bubble (boil) at room temperature when I pulled on the plunger, decreasing the pressure inside. Thus, water at a lower temperature boils at a lower pressure, as shown by the phase diagram when the line trends from upper left to lower right.

The water boiled—turned to a gas—when I decreased the pressure at a constant temperature. This means that the gas is above the line and liquid below. This also makes sense with water boiling on the stove, where I increased the temperature at constant pressure until the liquid turned to gas—thus the gas is on the right.

You need two points to determine the trend of the line. You can get one point by measuring the temperature at which water boils at 1-atmosphere pressure by bringing a pot of water to boil and measuring its temperature. Both liquid water and gas coexist at this temperature, so that gives you one point to define your trend. Put that point on your graph.

For the second point, put some water in your syringe and remove ALL of the gas bubbles from it. Put your thumb over the end of the syringe so that no air can get in and water can't leak out (you might use the balloon to protect your thumb from the pressure or vacuum inside the syringe).

Now, alternately push on the syringe plunger or pull on it to try to get the water inside the syringe to boil (watch for the formation of lots of bubbles as it starts to boil.

From this information, you can figure out which trend on the graph is correct, and on which side of the trend to put 'liquid' and which side to put 'gas'.