Mr. Rasmusen

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  **Handout: Altitudes and Proportions**

 You should all memorize the boiling point of water, which is 212 degrees Fahrenheit (also learn how to spell “Fahrenheit”). But this is actually a little misleading. The temperature of 212 degrees is the boiling point at sea level, but it changes with altitude. It’s quicker to boil water at higher altitudes, up on a mountains.

 A place’s altitude is defined by how high it is above sea level. Thus, the altitude at sea level is 0 feet.[[1]](#footnote-2) The altitude of Denver, Colorado is 5,280 feet, which is why it’s called the Mile High City. There, water boils at 202 degrees. Water can’t get any hotter than its boiling point, because if it does, it turns into steam (steam can get much, much hotter, which is why it is more dangerous). This means that cooking recipes have to be modified if you’re cooking in Denver. (Question: do you need to boil noodles longer there, or for a shorter time?) Bloomington, Indiana is at 771 feet and has a boiling point of 211 degrees. Pike’s Peak, Colorado, is at 14,115 feet and has a boiling point of 186 degrees. The Dead Sea is at -1,411 feet and has a boiling point of 215 degrees.

  **Mt. Everest is 29,000 feet high. At what temperature does water boil there, if you’ve climbed all the way to the top with your camp stove?** Figure it out, write down your estimate on your homework, and then check it using one of the websites below (you have to find the right one).

https://hypoxico.com/pages/altitude-to-oxygen-chart

https://www.engineeringtoolbox.com/boiling-points-water-altitude-d\_1344.html

https://www.mide.com/air-pressure-at-altitude-calculator

 Why does water boil at a lower temperature in Denver than in Bloomington? The reason is that air pressure is lower. Air has weight. It is very light, but it’s heavier than you think. A cubic yard of air—3 ft by 3ft by 3ft-- weighs 2 pounds. If you were lifting a cubic yard box that had a vacuum inside, so it was airless and truly empty, it would be 2 pounds lighter to lift.

 Since air has weight, the air is pushing down on us all the time. It’s considerable pressure, though we’re used to it: 15 pounds per square inch. Since there are 144 square inches in a square foot, that’s 144 x 15 = 2,160 pounds per square foot, over one ton per square foot! You can be proud you’re strong enough to stand up without getting crushed. But if you go higher, there’s less air above you, so the air pressure is lower. In Denver, it’s only 8 pounds per square inch. When water boils, its molecules are rising up from the water as they become a gas. In Denver, they have less pressure to fight against when they try to rise up, so they boil off quicker.

1. You might ask yourself “How high above sea level where? Do we use New York or Tokyo?”. It turns out not to matter. Why not? (But you can’t use the level at the edge of the Caspian Sea. Why not?) [↑](#footnote-ref-2)