Combining Substances

Calorimetry tells us that different substances can absorb different amounts of heat, even if they are the same temperatures. Because of this, when we combine substances with different specific heat capacity values, we have to take those values into account when finding the final temperature.

This is yet another situation where we can apply the law of conservation of energy. When we combine two substances together, the amount of thermal energy that one substance loses during the combination will be exactly equal to the amount of thermal energy that the other substance gains.

To express this as a mathematical equation, we can say Q lost plus Q gained equals 0. Recall from earlier in the lesson that Q is equal to mc delta T, where m is the mass of the substance, c is the specific heat capacity, and delta T is equal to T final minus T initial. So another way to write this definition is Q is equal to mc times T final minus T initial.

The substance that gets hotter will have a positive delta T, and the substance that gets colder will have a negative delta T. The hotter substance will always be the one to lose thermal energy during a combination of substances, and the colder substance will always gain energy.

To better understand this, let's go to the whiteboard and look at an example. The example reads, a 0.289 kilogram piece of aluminum at 30 degrees Celsius is added to 0.162 kilograms of water at 93.3 degrees Celsius in an insulated container. If no heat is lost to the environment, what will the final temperature of the mixture be?

Well, let's begin by writing down first everything that we know about the aluminum. The mass of aluminum is equal to 0.289 kilograms. The specific heat capacity c of aluminum we can find by looking at our chart of values, and we'll see that it is 899 joules per kilogram degree Celsius. And lastly, the delta T of aluminum is equal to T final, the value we're trying to find, minus T initial, which is 30 degrees Celsius.

Now let's write down the values that we know for water. The mass of water that we have, m, is equal to 0.162 kilograms. Specific heat capacity of water we find by looking at the table of values, and we find that that's 4,186 joules per kilogram degree Celsius. And lastly, the delta T of water is equal to T final, which will be the same T final as aluminum, minus the T initial, which for the water was 93.3 degrees Celsius.

So let's give ourselves a little space and enter these values into the equation. That equation says that the sum of the delta T values will be equal to 0. So mc delta T for aluminum is 0.289 kilograms times c, which is 899 joules per kilogram degree Celsius, times delta T, which is T final, minus 30 degrees Celsius. That plus the mc delta T for water, which is 0.162 kilograms, times 4,186 joules per kilogram degree Celsius, times delta T, which is T final, minus 93.3 degrees Celsius. The sum of those two values is 0.

This is a pretty messy equation, so let's simplify it. Simplifying the values for aluminum, we get 259.8 joules per degree Celsius times T final, minus 30 degrees Celsius plus-- multiplying these values together gives us 678.1 joules per degree Celsius times T final minus 93.3 degrees Celsius equals 0.

Now we're going to use the distributive property and distribute these values across the values inside the parentheses. Doing that gives us 259.8 times T final minus 7,794.3 plus 678.1 times T final minus 63,270 equals 0.

If we add 7,794.3 and 63,270 to both sides of the equation and combine these like terms here, what we get is 937.9 times T final equals 71,064. Dividing both sides of this equation by 937.9 gives us that T final, the final temperature of both the water and the aluminum, is equal to 75.8 degrees Celsius.