An Introduction to Matter and Measurement

Properties of Matter

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This is my stuff. Oh, sorry, this is my stuff. And my stuff has physical properties. It has things like mass, and it has volume. And it also has a temperature. We could determine its temperature. And we talked previously about physical phase, whether something is a solid, or a liquid or a gas. And so my particular stuff here is clearly a solid. But it has some other properties, in principle. I mean, this is a symbol for stuff. And it could have a melting point, and it could have a boiling point. And it has more qualitative things. So most of the things I've talked about up until now are quantitative. But it could have qualitative physical properties, things like color, or odor, or taste. Which is not to say that you should always taste or smell your stuff, but that is a physical property. And what's a physical property? It's something that you can measure about your stuff that doesn't involve changing its composition.

So changing its composition would involve a chemical property. In other words, chemical properties are about reactivity. How does your stuff react with something else? And in order to determine how it reacts with something else, you have to do a chemical change, and I'll talk about that more later on. But two examples of chemical properties are flammability. If you heat something up, is it going to catch on fire? At what temperature does it catch on fire? Or water sensitivity. If you put it in water, does something happen to the stuff that signifies that it has reacted with the water?

Now, we can define or subdivide physical properties into two categories. We have intensive, and an intensive property is something that does not depend on the amount of stuff. And examples of intensive properties are density, temperature, boiling point. For instance, if you have a pot of water and you measure its boiling temperature, it'll be 100 degrees Celsius. If you have two pots of water or a bigger one pot of water, that's a better example, if you have a huge pot of water and you measure the temperature at which the water boils, it's still going to boil at 100 degrees Celsius.

In contrast, extensive properties do depend on how much stuff you've got. If I weigh one paper towel or one stuffed model, it'll weight a certain amount, and if I weigh two of these, it's going to weight twice as much. And so that's an example of an extensive property. And another one that you'll be familiar with is volume.

Now, let me talk a little more about density and, unfortunately, this might be the only thing that you remember about chemistry 20 years from now. Density we said was an intensive property, and it turns out that it is the ratio of two extensive properties, mass and volume. Here is a demonstration of density. It turns out that low density things float in higher density things. So here I have a diet pop and a regular pop. And suppose you're at a party some time, the lights are off, there's a cooler, it's got drinks in it. Suppose you really hate diet pop, or you really hate sugared pop, it doesn't really matter. And you reach into the cooler, but it's dark, and you have to figure out whether you've just grabbed a diet pop or a regular pop. Well, it turns out that they are separable by their density, and you may have noticed this before, but it was news to me. Well, that's not too impressive. Oh, I know, there's a bubble underneath it. It turns out that diet pop has a lower density than does sugared pop. And so diet pop floats and sugared pop sinks. And so if, in the dark, you reach into the cooler and you want a diet pop, reach for something that's floating on top. And, incidentally, the thing you're probably more interested in is the fact that beer floats.

All right, so now let's talk about changing these physical properties. And a physical change is a change in a physical property without a change in its identity or composition. Actually, let me get a couple of people to remove this aquarium and I'll show you another demonstration.

In contrast, a chemical change is a chemical reaction. Something is happening to our stuff that changes its identity or composition. So the classic example of that is, what I have here is a hot plate, and the hot plate is hot. And what I have here are some candles. And what you can see here is the hot plate is hot and I put a piece of candle into the hot plate, what happens is it starts to melt. But what's in the hot plate and in the petri dish is still wax, it's just changing its physical state. It's going from being a solid to being a liquid, and you see a dish here of melted wax. But in contrast, when I light these candles, now what is going on is a chemical change. What's happening is the wax is reacting with air, excuse me, oxygen in the air to form carbon dioxide and water and what's left over is no longer wax, no longer identifiable as wax. It's changed its composition, changed its identity to be something entirely different, carbon dioxide and water.

Well, what we've talked about here are yet more ways that we categorize our world, in particular, what we've got, and what scientists do is they go through and they've tabulated these things, or they've written them down. And it turns out that things like boiling point and melting point uniquely characterize a substance. So if you have a substance that

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melts at 0 degrees C and boils at 100 degrees C, that's water. Nothing else boils at exactly 100 degrees C and exactly melts at 0 degrees C. So you can see that physical properties and chemical properties are really important for categorizing and organizing our world.