Physical Properties

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CHAPTER 1

Physical Properties

For the 2000 Summer Olympics in Sydney, Australia, Wendy Craig Duncan carried the Olympic torch underwater, with the flame burning! How many different states of matter can you find in the picture. Reviewing physical and chemical properties, you will learn about the four states of matter and the properties of matter.

Matter

What exactly is matter? Well, everything you can see, touch, smell, or taste is matter.

Matter **is anything that has mass and takes up space.**

Is the chair you are sitting on matter? Does it have mass? Does it take up space?

Is grass matter? Does it have mass? Does it take up space?

Are you matter? Do you have mass? Do you take up space?

Is air matter? Does is have mass? Does it take up space?

Physical Properties and Changes

Goals

1. Identify physical properties of matter.
2. Explain why materials with different masses have different densities.
3. Describe the states of matter.
4. Determine how temperature changes affect substances.

You use your senses to make observations. Any characteristic of a material that you can observe or measure WITHOUT changing the identity of the material is a physical property.

Color, Shape, Size

So, let's start with the figure above showing the laundry detergent bottles. Your first observation might be that the bottles are all different colors. By observing the different colors, did you change the bottle in any way? Or is it still plastic? Just because you observed the color of the bottles doesn't mean you changed it. The identity of the bottle (plastic) did not change. We have mentioned the bottles are all made out of plastic, so now, let's talk about the shape of the bottles. Are all the bottles the same shape and size? By changing the shape and size of the bottles, did we change the identity of the bottles? No, the bottles are all still plastic. These three properties (color, shape, size) are all physical properties because they are properties that can be observed without changing the identity of a material.

Length, Mass, Volume

Let's look at a few more physical properties that can be measured. When using the physical property of length, you would use some type of tool to measure, such as a ruler, meter stick, or tape measure. Take this loaf of bread, for example. Can you use a meter stick to measure the length of the loaf? Sure you can, but did you change the identity of the bread? No, the bread is still bread. How about this, when you cut the bread into slices, did you change the size of the loaf? Will the measurements of the slices be different than the whole loaf? Yes to both questions, but even though you changed the size and the measurements, did you change the identity? No, the bread is still bread.

What about the mass of an object? First of all, what is mass? Mass is the amount of matter in an object. So, back to the laundry detergent and the loaf of bread. Will the mass of the whole loaf be the same as one slice of bread? No, but did it change the identity of the bread? No, it is still bread. The same would be true for the laundry detergent. Will one cup of laundry detergent have the same mass as the whole bottle? No, but did we change the identity of the detergent? No, it is still detergent.

What about the volume of an object? Volume is the amount of space an object takes up. If we pour some juice into a glass, did we change the volume from the original container. Yes, but did we change the identity of the juice? No, the juice did not change into something else just because we poured it into another container. The identity did not change.

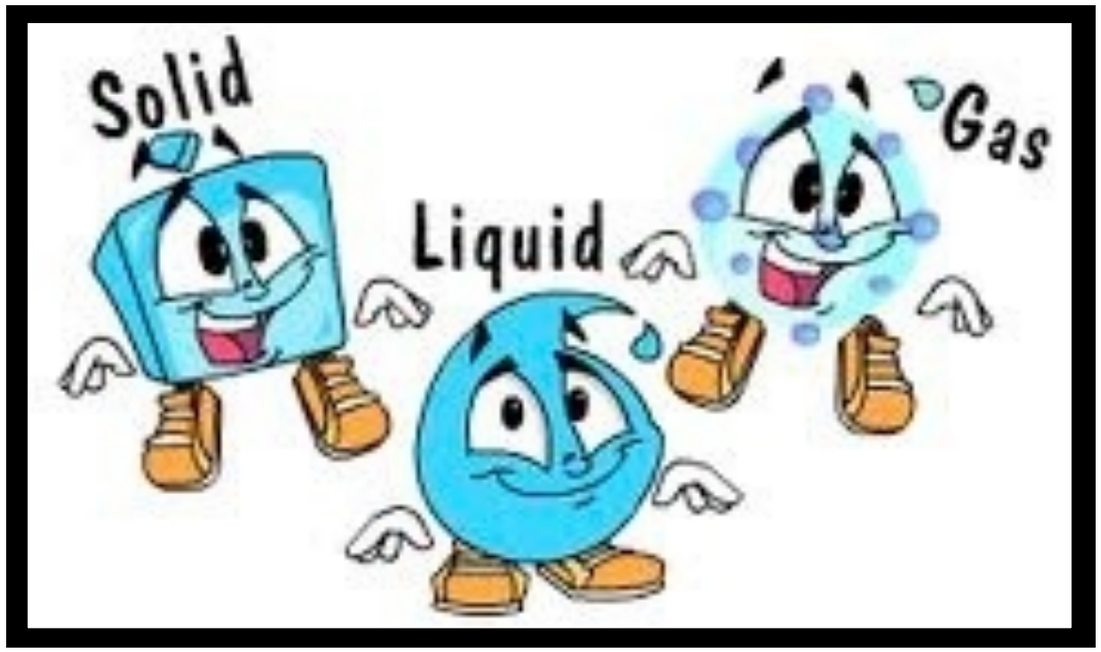
Density

Density is a physical property that combines the mass and volume. Density is the amount of mass a material has in a given volume and can be measured using the following formula: Density = mass/volume, or D = m/V. So, to put this in simple terms, when you try to pick up two things that are the same size (volume) but one is heavier than the other (mass), you have observed density. Not only can you observe it, but you can measure it using the formula mentioned above. Let's look an example.

Look at the definition of density again, the amount of mass a material has in a given volume. A kickball and a bowling ball are real close to the same size (volume), but one is obviously much heavier than the other (mass). Which of the two has a greater density? The bowling ball will have the greater density, why? If the volumes are the same, but the masses are different and then divide the mass by the volume, the number (density) will be greater for the bowling ball. BUT, it all goes back to the identity of the substance. Did we change the kickball or the bowling ball by measuring the density? No, so measuring density is a physical property.

The density of a material will stay the same as long as the pressure and temperature stay the same. What happens to the density of water when temperature drops and it changes from a liquid to a solid? Liquid water has a density of 1.00 g/cubic cm, but frozen water has a density of 0.9168 g/cubic cm. Did the identity change? No! It is still water, just in a different state. Which brings us to the next section

States of Matter



AND?

Everyone has always been taught the states of matter are solid, liquid, and gas, but with the advancements in research and technology, is there something else? Let's take a look!

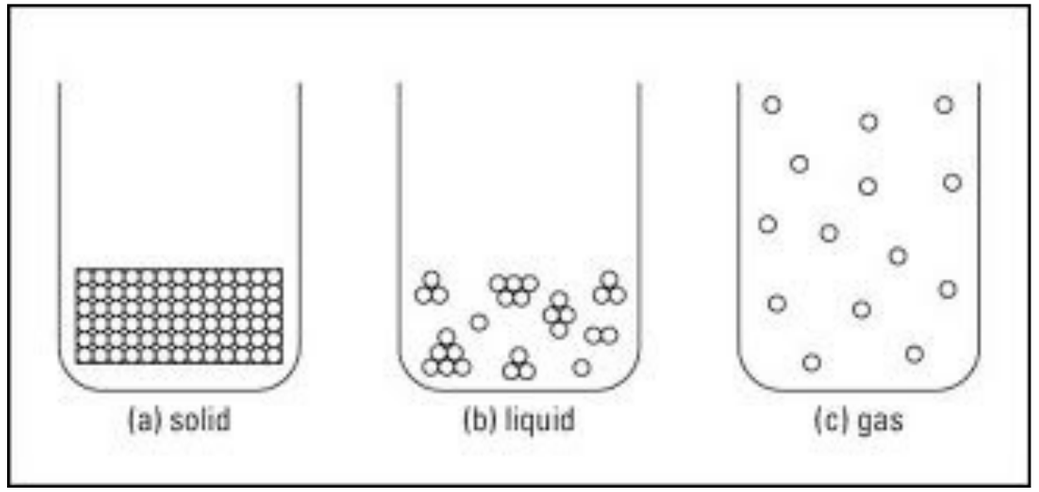
When we think or talk about the states of matter, most people go straight to water and how it is a solid (ice), liquid (liquid water), or a gas (water vapor). While this is true, water is not the only thing that changes it state, but let's start with water since it is the most common matter that we are familiar with.

When we look at liquid water, ice, and water vapor, we tend to say that states of matter is not a physical property, but it is. Just because liquid water froze to become ice, did it change the identity? No, it is still water just in a different state. What caused the change of state? The state of matter depends on temperature and pressure. For liquid water to freeze, the temperature must drop.

What is sometimes difficult to understand is that matter is made up of moving particles, and these particles move faster when higher temperatures are applied. Watch this short video to see a demonstration.

Movie 1.1 How particles move when different temperatures are applied.

So, particles of matter move at different speeds when temperature is applied. Let's compare moving particles at different states.



In the figure above, we see how the particles are arranged and moving in solids, liquids, and gases. Let's look at a solid first. As you can see in the diagram, the particles are in a fixed position and remain close together. Particles in a solid may not be moving around but they are moving by vibrating in place. Since the particles are in a fixed position, it gives the material a definite shape. Moving on to a liquid, you can see that the particles are moving around. The particles are moving much faster and have enough energy to slide past one another. This allows the material to take the shape of the container. In this example, the liquid would take the shape of the cylinder it is in. The particles of a gas are moving so quickly that they have enough energy to move freely away from other particles. These particles will take up as much space as possible and fill any container. What happens to these particles if the lid is opened?

Well, there are the three most common states of matter. What about they AND? I referred to at the beginning?

The fourth state of matter is called plasma. The plasma state is not a common state that you would see during every day activities. Plasma occurs at very high temperatures and is an extremely hot, electrically charged gaseous material. Plasma makes up 99% of the visible matter in the universe, but it is rare on Earth. Plasma is found in fluorescent bulbs, laboratories, and lightning.

Since we are talking about how matter changes state due to temperature changes, we should include in this section two more physical properties: melting point and boiling point. These two physical properties allow you to identify a substance by the temperature at which the substance either melts or boils. Let's look at water and chocolate.

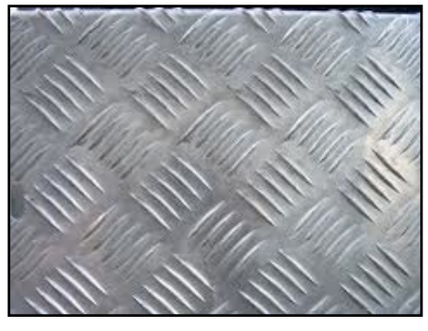
Melting point is the temperature at which a solid becomes a liquid. It doesn't matter if you are trying to melt one ice cube or a truck load. The temperature both will melt will be 0 degrees Celsius. Will chocolate melt? Sure it will, but will it melt at 0 degrees Celsius. No, because is has its own unique melting point. Every substance has its own unique melting point and that is what enables us to identify substances. Example: if you found a solid piece of material that was clear and cold, you might assume that it is ice. To confirm that it is ice, you could record the temperature at which it melts. If it melts at 0 degrees Celsius, then it is likely to be ice. But what if it melts at 12 degrees Celsius? Do you know what the substance is?

No, but you know what is isn't. The same hold true for boiling point. Boiling point is the temperature at which a liquid becomes a gas. Again, let's use water as an example. We know that water boils at 100 degrees Celsius. You find a clear liquid that looks like water. To confirm this, you could heat it up and record the temperature at which it boils. If it boils at 100 degrees Celsius, then it is water. If it boils at some other temperature, whether higher or lower, you know it is not water. Do you know what the substance is? Probably not, but you what is isn't. Bottom line, whether a substance melts or boils, the identity has not changed only the state.

Other Physical Properties

Materials made of metal have their own unique set of physical properties.

Metals have a property known as luster. Luster is the shiny appearance of metals. Can you automatically say that something shiny is a metal? The figure shows wheels that you might see on a car or truck.



Metals also have a characteristic of malleability. Malleability is the ability for metals to be hammered, pressed, or rolled into thin sheets. The figure shows a piece of metal hammered and pressed into a piece of sheet metal.

Ductility is similar to malleability where this property gives metals the ability to drawn into thin wires, like copper.

Ductility is the process where the metal is heated to the melting point to become liquid. The liquid metal is run through a machine to get the size of wire as a liquid and then cooled very quickly to change back to a solid.

Malleability works in much the same way. The metal is heated to a soft, flexible state where it can be hammered, pressed or rolled to the desired shape and size.

The last physical property for metals is one you are probably most familiar with, magnetism.

Magnetism is the ability of a metal to attract a magnet.

All of the properties that we have discussed in these sections are all physical properties because they can be observed or measured without changing the identity of the substance.

Check out some of these videos for more information.

http://www.youtube.com/watch?v=xYFAj50c7xM&feature=related

http://www.youtube.com/watch?v=j2KZmRIKea8&feature=related

http://www.youtube.com/watch?v=OkuDM3hYutI

Review

Review 1.1

Physical properties are characteristics that can be changed by measurement.

- **A.** Yes
- **B.** No ✓
- **C.** Maybe
- **D.** None of the above

Check Answer

Review 1.2

Which of the following would be an example of a physical property?

- **A.** a nail rusting
- **B.** campfire burning
- **C.** puddle drying up after a rain ✓
- **D.** all of the above

Check Answer

Review

Review 1.3

Which of the following is an example of a physical property?

- ✓ **A.** forming a bar of copper into a wire
- **B.** frying an egg
- **C.** shooting off fireworks
- **D.** None of the above

Check Answer

Review 1.4

Particles of _____ states are in motion.

- **A.** solid and liquid
- **B.** liquid and gas
- **C.** gas and plasma
- ✓ **D.** all of the above

Check Answer

Review

Review 1.5

Which of the following could you use the physical property of shape to compare?

- **A.** salt and sugar
- **B.** strawberry and vanilla ice cream
- ✓ **C.** a baseball and a football
- **D.** cubes of frozen water and lemonade

Check Answer

Review 1.6

What property easily changes in gases but does not easily change in solids?

- **A.** mass
- **B.** color
- ✓ **C.** shape
- **D.** smell

Check Answer