

Energy is a word that we often use in our daily lives. For example, you would say "I used all my energy preparing for the test." However, energy is also a term often used in science which you may be already familiar with. Solar panels convert solar energy into electrical energy; wind turbines convert the energy of wind into electrical energy; hydroelectric power plants convert the energy of water into electrical energy and nuclear power plants convert nuclear energy into electrical energy. Once the various forms of energy are converted into electrical energy, we can use it in the form of electricity, by charging our cell-phones, using a microwave oven, turning on the light, and etc.

When we charge our cell-phones, the electrical energy is converted into a form of chemical energy inside the battery, which in turn will be later converted into sound energy and light energy when we actually use the cell-phones. When we use the microwave oven, the electrical energy is converted into microwave energy. When we turn on the light, the electrical energy is converted to light energy, and so on.

So far, we have seen that energy can be converted into different forms. Actually, it turns out that energy can never be destroyed or created; it can only be converted into different forms. When we create electricity by a solar panel, the electrical energy is not created from out of nowhere; it's just that solar energy is converted into electrical energy. Similarly, when we use electricity, the energy is not destroyed. The electrical energy is converted into other forms of energy. In such a case, the decrease in electrical energy matches the increase in the other forms of energy. In other words, that energy can never be destroyed or created means that the total amount of energy is conserved. This is known as "conservation of energy," or "the first law of thermodynamics." It was established in the 19th century.

In the 1920s, scientists were puzzled by their observations that energy conservation didn't seem to hold during a radioactive decay known as "beta decay." Nobel laureate Niels Bohr suggested that energy conservation was violated in the microscopic world. However, in 1930, to save energy conservation, Wolfgang Pauli suggested that yet unknown particle was produced during beta decay, carrying a portion of energy, but omitted in the calculation of the sum of energy of products after beta decay, as it was undetected. This unknown particle, now called "neutrino," was detected in 1956. A sacred principle such as conservation of energy is not easily overthrown!

Even though there are various forms of energy, they can all be traced back to kinetic energy or potential energy. Kinetic energy is due to the motion of particles or objects. For example, a moving car has kinetic energy. If you press brake pedal when driving a car, the friction between the road and the wheel converts the kinetic energy of the car into the heat energy in the wheel and the road; the wheel and the road get slightly warm. Heat energy is also a form of kinetic energy. The molecules in the wheel and the road vibrate faster when there is more heat. The kinetic energy of molecules is the heat energy. Warm object is warm because its constituent molecules move fast, having lots

of kinetic energy. On the other hand, a cold object is cold because its constituent molecules move slowly, having little kinetic energy. In the next article, we will describe how scientists came to realize that heat is a form of energy. Wind energy that turns wind turbines is also a form of kinetic energy. The air molecules in the wind move fast turning the wind turbines.

Potential energy has the potential to be converted into kinetic energy. For example, if a ball is at a high place, it has potential energy, because when dropped it has now kinetic energy; potential energy has been converted into kinetic energy. Chemical energy and nuclear energy are other examples of potential energy.

So, why is energy conserved? According to Noether's theorem, for every symmetry, there is a conserved quantity. It turns out that the conserved quantity for "time-translational symmetry" is energy. So, what is time-translational symmetry? Suppose you perform physics experiments today and perform the same physics experiments again with the same conditions ten days later. Then, you will get the same result. This is an example of time-translational symmetry. We will talk more about this in a later article. Before doing so, in the next article, we will explain how scientists came to realize that heat is a form of energy in the next article.

Summary

The energy may be converted to a different form, but the total energy is always conserved.