HANDS-ON CHEMISTRY

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Chapter 1

Lesson 1.1 Energy

What Is Energy?


Energy is needed to cook food.

Has anyone ever told you that you have a lot of energy? What does "energy" mean? **Energy** is the ability to do work. It's what allows anything to move, heat up, give off light, or change shape. Without energy, nothing would happen! It takes energy to do anything, from turning on a light, to cooking food, to running a machine. We don't see energy, but it's all around us.

Sources Of Energy

Where does energy come from? There are many sources of energy, which are divided into two categories: **nonrenewable** and **renewable**.

- **Nonrenewable** means energy that comes from something that is natural (not man-made), such as coal, oil, or natural gas. We only have a limited amount of them, and as they supply us with energy, they get used up.
- **Renewable** means energy that comes from a source that can't be used up, such as sunlight, water, and wind[1]. No matter how much of these sources we use, there will always be more of them.

Potential vs Kinetic Energy


Potential energy and kinetic energy are the two types of energy you use when you go down a slide.
Credit: MisterZero, Wikimedia.

Have you ever been on a playground slide? You may have guessed that you use energy to go down it. But did you know that you are actually using two different kinds of energy? One type is potential (stored) energy, and the other is kinetic (moving) energy. Potential energy means energy that is stored and ready to go. Kinetic energy is the actual movement of the object. So, when you're just sitting at the top of the slide, you have potential energy. The moment you start to move down it, the energy becomes kinetic.

Another way to understand this is imagining a basketball. When you're holding it in your hands, it has potential energy because the energy is stored. When you let go of it and throw the ball, the energy becomes kinetic because it is moving, or working. One more example: A book lying at the edge of a table has potential energy, because the energy is stored and it's ready to move. As it's knocked off and it falls to the floor, it has kinetic energy because it's in motion.

Types Of Energy

Batteries use chemical energy to make things work.
Credit: Marzie, Freeimages.

As we've explained, everything uses energy, whether cooling down a room, driving a car, or eating. But as you can see, these are all very different types of actions, and therefore need a different kind of energy to work. There are actually many different types of energy. Some of them are: **thermal** (heat) energy, which warms things up, such as heating a house or baking a cake; **mechanical** energy, which makes things move, like riding a bike or banging a hammer; **electrical** energy, which powers things such as washing machines or air conditioners; **radiant** energy (the only type of energy we can see), which gives us light like sunlight or a burning candle; and **chemical** energy, which is used in batteries or to power an engine.

Energy Conversion

After you eat a chocolate bar or candy, do you feel like you have more energy to run around or do things? That's because energy can change into another form of energy. The chemical energy in food **converts** (changes) into mechanical energy that makes you able to move and talk.

Windmills convert the energy of wind into electricity.
Credit: DXR, Wikimedia.

The sources of energy we mentioned earlier are all converted into another form of energy to benefit us. The energy of the wind, for example, can be converted by a windmill into mechanical energy to make electricity. (Today, wind turbines are used to do this.) Coals have chemical energy, which is changed into thermal energy when it is burned[2]. An electric kettle uses electrical energy from the socket, which is converted into mechanical energy (to work) and thermal energy (to heat). The fuel in a car has chemical energy, which is converted into radiant and thermal energy when it starts to move.

How To Optimize Energy

It's very important for us to **conserve** (save) nonrenewable sources of energy as much as we can, to stop them from running out. Conserving energy also makes the environment healthier and better for us by reducing air and water pollution.

We can do our bit to help by being **energy efficient**, which means saving or using less energy. When you turn off a light in a room that's not being used, or switch off the faucet while you're brushing your teeth, you are saving energy. LED lightbulbs give the same amount of light as other types of older bulbs, but they use less energy. When you recycle things like plastic bottles or paper, it conserves energy. This is because using something for a second time uses less energy than making it new, aside from using up less resources.

How Is Energy Connected to Chemistry?

Everything around us is made up of particles called atoms, which are so tiny that we can't see them. Atoms are **bonded** (connected) to each other. When a bond is broken, energy is used, and when a new one is made, it releases energy. This is how a process called chemical reaction occurs.

Rust is a chemical reaction of iron, water and oxygen.
Credit: Myfreeweb, Wikimedia.

You may not realize, but there are chemical reactions happening a lot in your day-to-day life! Ever left your bike in the rain? Not a great idea, because it will start to rust. Rust is a combination of iron (the metal of a bike), water, and oxygen, which cause a chemical reaction. Rust is not the metal wearing away, but is actually an entirely new chemical formed using energy.

Word Match:

Conserve	Energy coming from a source that is natural
Energy efficient	Energy that is stored and not yet being used
Kinetic energy	Saving energy
Renewable	The energy of an object that is moving
Energy	Saving and using less energy
Energy conversion	The ability to do work
Nonrenewable	Energy changing into another form of energy
Potential energy	Energy coming from a source that can't be used up

Review Questions

1. What is the difference between potential energy and kinetic energy?

2. Why are sunlight, water, and wind called renewable resources?

3. Why is it important to be energy efficient? Can you think of another 3 ways to save energy that were not listed?

4. How does energy play a role in chemistry?

Exercise

Throwing with Arm	
Trial	Distance Traveled (cm)
1	
2	
3	
4	
5	
6	
7	
8	
9	
10	
Average Distance Traveled	

Exercise

Airplane Launcher	
Trial	Distance Traveled (cm)
1	
2	
3	
4	
5	
6	
7	
8	
9	
10	
Average Distance Traveled	

Lesson 1.2 Matter

What is Matter?

A cup of water is made up of matter.

What do your clothes, a basketball, a cup of water, and the air you're breathing all have in common? They are all made up the same thing - **matter**. Matter means anything that takes up space, which, in other words, is everything! Everything around us has matter, whether or not you can see, feel, touch, or smell it.

Matter is defined by two things **mass** and **volume**. Mass is the amount of matter something has in it (it's weight). Volume is how much space something takes up (it's size).

Explaining Matter

There are three different states of matter: **solid, liquid, and gas**[1].

A book is one example of a solid.

- **Solid** is something that has a fixed size and shape, and it doesn't change. Anything you can pick up, hold, and feel is a solid. A book is a solid because its shape and volume stay the same, even if you move it from one place to another. A pen, a banana, and a piece of wood are all examples of solids.
- **Liquid** has a fixed volume (amount), but it takes on the shape of whatever container it's in. Anything that flows when it's poured is a liquid. Milk is a liquid, so it has the shape of the bottle that it's in, but if you would pour it into a square container, that's the shape it will take. Although its shape changes, the amount of milk stays the same. Water, oil, and soap are also examples of liquids.
- **Gas** is something that doesn't have a fixed size or shape, but it takes on the shape and volume of whatever space it has available. We can't always see gases, but they are all around us. Oxygen, carbon dioxide, helium, and nitrogen are all gases when they are at room temperature.

Is Water a Matter?

Here's an easy way to understand that water is a matter, and that it has both mass and volume. Imagine you have an empty bucket in front of you. Now picture it being filled with water until the top. The bucket will be a lot heavier now than when it was empty! This shows that water has mass, because the bucket weighs more when it has water in it.

Besides being heavy, the bucket is also now full, which means that water takes up space. Now you know that water also has volume!

Is Air a Matter?

Like air, we can't see most gases around us. So how do we know that gas has mass and volume? There is actually an easy way to see; all you need is an empty balloon. Imagine you're blowing into a balloon. The more air you blow into it, the bigger it gets. This means that air has volume, because it's taking up space inside the balloon. A balloon with air in it is heavier than an empty balloon, showing that air also has mass.

Balloons show that air has mass and volume.

Identifying Matter

You can tell the difference between a ticket and a tissue in your pocket because one is hard and one is soft. Hard and soft are both examples of **physical properties**, which are different ways to identify matter. Physical properties are used to described something that can be seen or measured, without the object changing. There are many ways to identify an object besides hard and soft. Shape, size, color, smell, and freezing or boiling point can all be used to describe objects.

High flammability is a chemical property of paper, which turns into ash when it is burnt.

Another category of properties we can identify matter with is **chemical properties**. This refers to properties that can be seen or measured only when an object changes to become a totally new matter. Flammability (burning) is one example of this. Another example is when paper turns into ashes, which is a completely new matter, when it touches a flame. Rusting is another instance.

Energy Moving Through Matter

Energy moves through matter (solids, liquids and gas), and also through empty spaces (called a vacuum), in waves. Waves are a disturbance that transfer energy from one place to another place. An example is the up-and-down motion of waves in the sea that's caused by a disturbance to the water. These waves transfer energy along the water (a liquid).

There are also other kinds of waves, like sound waves which travel through the air (a gas) to your eardrums, making noise you can hear. A microwave uses waves to heat up food fast, and an x-ray uses waves to make a picture of the inside of your body[2].

Sea waves transfer energy along the water.
Credit: Alvesgaspar, Wikimedia

Word Match:

Mass	The amount of space something takes up
Physical properties	Something that has a fixed size but changes shape
Solid	Properties that can be seen or measured when the object changes
Vacuum	The amount of matter something has
Chemical properties	Something that has no fixed shape or size
Gas	Properties that can be seen or measured without changing the object
Volume	Movement of energy from one place to another without moving matter
Matter	Something that has a fixed shape and size
Liquid	An empty space through which sound waves can't travel
Waves	Anything that has mass and volume

Review Questions

1. What is matter?

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2. What are the three states of matter? Describe each one.

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3. What does physical properties of matter mean? Describe something using some physical properties.

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4. Explain how energy moves through matter.

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Lesson 1.3 Molecules in Motion

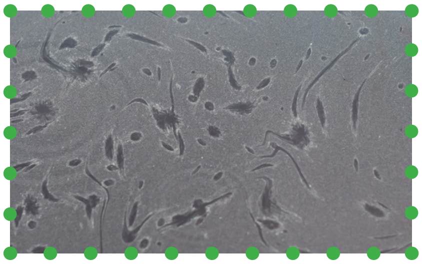
The Brownian Movement

Imagine someone is holding a fresh slice of pizza at the other end of the room. You won't be able to smell it right away, but if you wait a little, the smell will start to reach your nose. How does that happen?

Pollen comes from the yellow part of the flower.

To understand this, we need to go back in time, to the year 1827. A Scottish botanist (scientist who studies plants and flowers), called Robert Brown, was looking through a microscope at some pollen grains (powder from flowers) floating in water. He noticed that they were moving around the water in a random pattern. As a scientist, he tried to understand why they were moving the way they were. He thought perhaps it was because the pollen was alive, but when the same thing happened with some dust particles, which are not alive, he realized that this wasn't the explanation. In the end, he was never able to work out why the pollen grains were moving randomly in the water.

Understanding the Brownian Movement



Pollen floating in water through a microscope. *Credit: T.Smirnova, Wikimedia.*

Many years later, in 1905, Albert Einstein made the discovery of why this happened. He explained what is now called the Brownian Movement (named after Robert Brown). Water is made up of a lot of **molecules** (the smallest particles that make up something). Molecules are too small to be seen[1]. However, even though we don't see it, they are constantly moving around and bumping into each other. When Robert Brown was looking at the pollen grains, they were actually being pushed around by the moving water molecules. It looked like they were moving in a random pattern for no reason, but they were really being bumped around the invisible molecules.

To understand this better, picture yourself stuck in a large crowd that's not sure which way to go. People will bump into you from all directions. If people from the right bump into you, you will get pushed along with them to the left, but if a lot of people from behind suddenly bump into you, you will be pushed forward. This is kind of what happens in the Brownian Movement. The molecules in the water constantly bump into the pollen from all different sides, making them move randomly in all directions.

The Brownian Movement happens to molecules in a **fluid**, which means either a liquid or a gas.

Diffusion

One example of the Brownian Movement is **diffusion**. Diffusion is when the molecules move from an area where they are more concentrated to an area where they are less concentrated. This will occur until the molecules are evenly spread out. **Concentrated** means how much of something is in a certain place.

You may not realize, but diffusion often happens in your day-to-day life! Here are some examples. When smoke starts to form, it's very thick and all in one place. This means the smoke molecules are highly concentrated. As the smoke spreads around the room, the molecules diffuse to areas where they are less concentrated.

Tea molecules diffuse from the tea bag into the water, until they're evenly spread.

Another example of diffusion is a tea bag. There is a high concentration of tea molecules in the tea bag, and when it's dipped into the hot water, the molecules diffuse until the they have spread to the whole cup.

And back to our slice of pizza from the beginning. You can't smell it right away, but the pizza-smelling molecules diffuse from the pizza to the whole room, until they reach you. That's how you can smell it, even if you're far away from it!

Moving Molecules

Here's an interesting fact about tires: You may not know this, but the tires on your bike can deflate (get a little smaller) on a very cold day. This might seem strange, but let's do some explaining!

Molecules are always moving, but they move differently under different conditions. Molecules always move faster in a gas than in a liquid. When the temperature of a liquid or a gas becomes hotter, the molecules move faster. Faster moving molecules move further apart from each other. When the temperature cools down, the molecules move slower. Slower moving molecules move closer to each other[2].

Hotter	→	Faster	→	Further apart
Cooler	→	Slower	→	Closer together

If the temperature of a gas increases (gets warmer), the pressure will increase, and if the temperature decreases (cools down), the pressure of the gas will also decrease. On a very cold day, the molecules in a bike tire slow down, move closer together, and have less pressure. The same number of molecules take up less space. That's why the tire deflates a little when it's cold outside!

This can happen to cars, too. Because the pressure in the tires drop as the weather starts to get cold, a warning light often shows up in cars that the tire pressure is low!

The opposite happens when the weather is hot. When the temperature of the tire increases, the molecules move faster and spread out more. This makes the pressure higher, and the tire inflates (gets slightly bigger).

Bike tires can deflate on a cold day, because the air in the tire has less pressure.

Word Match:

Molecules	An area where there are fewer molecules
High concentration	A liquid or a gas
Brownian Movement	The spreading of molecules from an area of high concentration to an area of low concentration
Fluid	A tire getting smaller because of less pressure in the air
Deflate	The random movements of molecules in a fluid
Diffusion	The smallest particles that make up something
Low concentration	An area where there are more molecules
Inflate	A tire getting slightly bigger because of more pressure in the air

Review Questions

1. What did Robert Brown see when he was looking through a microscope? Can you explain the reason why this was happening?

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2. What does diffusion mean?

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3. How do molecules move differently when the temperature changes? Explain how energy moves through matter.

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4. If pressure decreases when the temperature goes down, what do you think will happen to a balloon that's put in a freezer, and why? *It will shrink. When a balloon cools down, the pressure of the air inside it will drop.*

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