# Heating and Cooling

# L1 Transfer of Heat

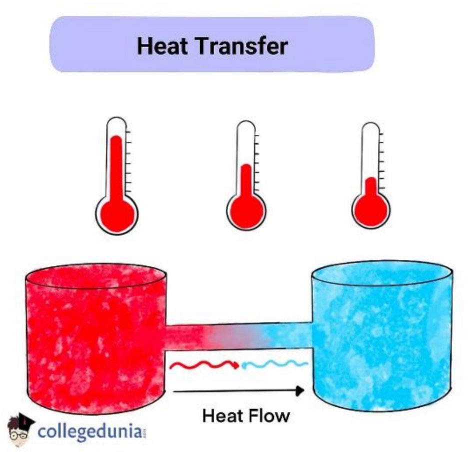
Imagine you're holding a cup of hot chocolate in one hand and a cold glass of lemonade in the other. Even though both drinks are liquids, one feels hot, and the other feels cold. This difference is due to heat energy.

What is Heat Energy?
Heat energy is a type of energy that comes from the movement of tiny particles called molecules and atoms. When something is hot, its molecules move very fast and have a lot of energy. When something is cold, the molecules move much more slowly and have less energy.

High Temperature Means More Heat Energy
Let's go back to our hot chocolate and lemonade. The hot chocolate has a high temperature because its molecules are moving really fast and carrying a lot of heat energy. The lemonade has a low temperature because its molecules are moving slowly and have less heat energy.

Think of it like a playground. If all the kids are running around really fast, it's like the hot chocolate with lots of energy. If the kids are just standing around or walking slowly, it's like the cold lemonade with less energy.

Heat Flows from Hot to Cold
Now, what happens if you put your hot chocolate and lemonade next to each other? Over time, you'll notice the hot chocolate cools down a bit, and the lemonade warms up. This happens because heat energy flows from the hot chocolate (where there's a lot of heat) to the lemonade (where there's less heat).




This flow of heat energy from a hot object to a cold object happens naturally and is a basic rule of how heat works. Heat always moves to places where there is less of it.

Heat Transfer and Thermal Equilibrium
Heat will continue to flow from the hot chocolate to the lemonade until both drinks reach the same temperature. This point, where the heat is evenly spread between them, is called thermal equilibrium. At thermal equilibrium, there's no more flow of heat energy because both drinks have the same amount of heat energy.

Imagine you and a friend are each holding one end of a jump rope. If you start pulling your end hard, the rope moves towards you, right? But if you both pull with the same strength, the rope doesn't move. That's like thermal equilibrium, where everything balances out.

Recap
High Temperature and Heat Energy: Hot objects have a high temperature because their molecules are moving fast and have a lot of heat energy.
Heat Flow: Heat energy always flows from hot objects (where there is more heat) to cold objects (where there is less heat).
Thermal Equilibrium: Heat continues to flow until the temperature is the same everywhere, achieving thermal equilibrium.
By understanding these concepts, you can see how heat energy affects the world around you, from your warm cup of hot chocolate to the sunlight that warms our planet.

Independent practice

1. What happens to the molecules in a hot object compared to a cold object?
2. Why does hot chocolate have a higher temperature than cold lemonade?
3. In which direction does heat energy naturally flow?
4. What occurs when heat flows from a hot object to a cold object over time?
5. What is thermal equilibrium?
6. Extended writing: How does the concept of thermal equilibrium explain the interaction between hot chocolate and cold lemonade when placed next to each other?
7. Why does a metal spoon feel hot when left in a pot of hot soup?
8. What is heat energy and how is it related to the movement of molecules?

# L2 Conduction and Radiation

**Conduction: Heat Transfer Through Particles**

Conduction is the process where heat moves through a solid material. Imagine you're holding a metal spoon in a pot of hot soup. After a while, you'll notice the end of the spoon in your hand getting warmer. This happens because of conduction.

**How Conduction Works:**

1. **Particles and Heat**: Everything is made up of tiny particles called atoms and molecules. In a solid, these particles are packed tightly together and can't move freely. However, they can vibrate.
2. **Energy Transfer**: When one part of the solid gets heated, the particles there start to vibrate more vigorously. They have gained energy from the heat.
3. **Passing Energy Along**: These vibrating particles bump into their neighbors, passing on some of their energy. Think of it like a row of people passing a ball from one person to the next. The ball represents the energy.
4. **Spread of Heat**: This process continues from one particle to the next, transferring heat through the material. The heat travels from the hotter end (near the soup) to the cooler end (where you're holding the spoon).

In summary, conduction happens because particles in a solid transfer energy by vibrating and colliding with each other.

**Radiation: Heat Transfer Through Waves**

Radiation is a bit different from conduction. Instead of needing particles to transfer heat, radiation can travel through empty space. The warmth you feel from the sun on your skin is a perfect example of heat transfer through radiation.

**How Radiation Works:**

1. **Electromagnetic Waves**: Heat radiation involves electromagnetic waves, which are waves of energy. These waves can travel through the vacuum of space, which means they don't need particles to move.
2. **Infrared Radiation**: Heat energy is often transferred in the form of infrared radiation, a type of electromagnetic wave that we can't see but can feel as warmth.
3. **Emitting Waves**: All objects emit some amount of infrared radiation, but hotter objects emit more. For instance, the sun emits a huge amount of infrared radiation because it's extremely hot.
4. **Absorbing Waves**: When these infrared waves hit another object, their energy is absorbed, causing the particles in the object to vibrate more vigorously, and thus, warming it up.

Think of it like this: the sun sends out waves of energy across space. When these waves reach Earth, they hit objects like the ground, water, and even your skin, transferring their energy and warming them up.

**Comparing Conduction and Radiation**

1. **Medium Needed**:
    - **Conduction**: Requires a medium, usually a solid, because the particles need to be close enough to transfer energy through collisions.
    - **Radiation**: Doesn’t require a medium and can travel through the vacuum of space.
2. **Method of Transfer**:
    - **Conduction**: Transfers heat through the direct contact of vibrating particles.
    - **Radiation**: Transfers heat through electromagnetic waves, which can move without particles.
3. **Speed**:
    - **Conduction**: Generally slower because it relies on particle-to-particle contact.
    - **Radiation**: Faster, especially across distances, because electromagnetic waves travel at the speed of light.

**Real-Life Examples**

1. **Conduction**:
    - **Cooking**: When you heat a pan on the stove, the heat travels from the stove to the pan and then to the food through conduction.
    - **Touching Objects**: When you touch something warm, like a heated seat, the heat transfers from the seat to your hand through conduction.
2. **Radiation**:
    - **Sunlight**: The sun warms the Earth through radiation. The energy travels through space and heats the planet.
    - **Campfires**: When you sit by a campfire, you feel warmth from the fire. This is radiation at work, as the fire emits infrared waves that warm you up.

Understanding these processes helps explain many everyday experiences, from cooking and feeling the warmth of the sun to the design of insulation in homes to keep them warm. By knowing how heat transfer works through conduction and radiation, we can better appreciate the physical world around us.

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<u>Independent practice</u>

1. How does conduction transfer heat through a solid material?
2. Why can radiation transfer heat through empty space, and what kind of waves does it use?
3. What are some real-life examples of conduction, and how do they demonstrate this type of heat transfer?
4. Explain how the speed of heat transfer in conduction compares to that in radiation, and why this difference occurs.
   on particles colliding.

Finish the Sentences:

5. Conduction requires particles to be close together, because…
6. Radiation can travel through space, but…
7. The heat you feel from the sun is due to radiation, and…
8. Describe the process of conduction using the idea of particles. Explain how heat is transferred from one part of a solid to another.
9. Compare and contrast conduction and radiation in terms of the medium they require and the speed at which they transfer heat. Give examples of each from everyday life.

# L3 Particles and temperature

Imagine you're looking at a bunch of tiny marbles, way too small to see with your eyes. These marbles are like the particles that make up everything around us—air, water, rocks, and even your own body! These particles are constantly moving, and how they move and how close they are to each other depends a lot on the temperature.

What are Particles?
Particles are the tiny building blocks that make up everything in the universe. They can be atoms, molecules, or ions. In different materials, these particles behave differently, and temperature is one of the main factors that affect their behavior.

Temperature and Particle Motion
Temperature is a measure of how hot or cold something is. When you heat something up, you're giving energy to its particles. Here's how it works with temperature and particle motion:

Low Temperature (Cold):

When something is cold, its particles don't have much energy.
They move slowly and stay close to each other.
In solids, particles are tightly packed in a fixed position, only vibrating a little bit.
Think of the particles as people standing close together and shivering a little bit.
High Temperature (Hot):

When something is hot, its particles have a lot of energy.
They move much faster and spread out more.
In liquids, particles move around more freely but are still close together.
In gases, particles move really fast and are far apart from each other.
Imagine the particles as people running around wildly, bumping into each other, and moving far apart.
How Spacing Changes with Temperature
Let's look at how the spacing of particles changes as you change the temperature:

Solids:

At low temperatures, particles in a solid are packed tightly in a regular pattern.
As the temperature increases, these particles vibrate more but stay in their fixed positions.
The solid might expand slightly as the particles vibrate more, but they don't move out of their places.
Liquids:

In a liquid, particles are close together but can move around each other.
When you heat a liquid, the particles move faster and spread out a bit more.
This is why liquids expand when heated; the particles take up more space as they move more quickly.
Gases:

In a gas, particles are far apart and move very quickly.
When the temperature goes up, the particles move even faster and spread out even more.
This is why a balloon expands when it's heated—the gas particles inside the balloon are moving faster and pushing against the balloon's walls more.
Everyday Examples
Ice Melting:
When you take ice (solid water) out of the freezer and let it sit at room temperature, it absorbs heat. The particles gain energy, move faster, and spread out, turning into liquid water.

Boiling Water:
If you heat water on the stove, the particles move faster and faster until they spread out so much they become gas (steam). That's why you see steam rising from boiling water.
Summary
At low temperatures, particles move slowly and stay close together.
At high temperatures, particles move fast and spread out.
In solids, particles are tightly packed; in liquids, they're close but move around; in gases, they're far apart and move quickly.
Understanding how temperature affects particle motion and spacing helps explain a lot about how the world around us works. Whether it's water boiling, ice melting, or the air in a balloon expanding, it all comes down to how particles behave when they gain or lose energy.

Independent practice

**Comprehension Questions**

1. What are particles, and what do they make up?
2. How does the motion of particles in a solid differ from the motion of particles in a gas at the same temperature?
3. What happens to the particles in a liquid when it is heated?
4. Why does a balloon expand when the gas inside it is heated?
5. What everyday examples are given in the text to explain how temperature affects particle behaviour?

**Understanding Questions**

1. Explain why ice melts when left at room temperature in terms of particle motion and spacing.
2. Describe what happens to the particles in a solid as it is heated but not to the point of melting.
3. Compare the behaviour of particles in a liquid and a gas when both are heated.
4. How does the concept of particle motion and spacing help explain the expansion of solids, liquids, and gases when heated?
5. Based on what you learned, predict what would happen to the particles in a gas if it were cooled down significantly.

# L4 Internal energy

**Understanding Internal Energy Stored in Materials**

Imagine you have a ball of clay. You can squeeze it, stretch it, or roll it into different shapes. Even though you can't see them, inside that ball of clay, there are countless tiny particles called atoms and molecules. These particles are always moving, even when the clay looks still. The energy that these particles have because of their movement and their positions relative to each other is called internal energy.

### What is Internal Energy?

Internal energy is the total energy stored inside a material. It includes two main types of energy:

1. **Kinetic Energy**: This is the energy that the particles have because they are moving. In solids, the particles are vibrating in place. In liquids, they can move around each other, and in gases, they move freely and quickly in all directions.
2. **Potential Energy**: This is the energy stored due to the positions and attractions between particles. Think of it like a stretched rubber band. When you stretch it, you give it potential energy. Similarly, particles in a material can have potential energy based on how they are arranged and attracted to each other.

### How Do We Measure Internal Energy?

We often measure internal energy by looking at temperature. When you heat a material, you add energy to it, making the particles move faster. This increases their kinetic energy, which we see as a rise in temperature. For example, when you heat water on the stove, the water molecules move faster and faster until they start to turn into steam.

### States of Matter and Internal Energy

Materials can exist in different states: solid, liquid, or gas. The internal energy changes depending on the state.

- **Solids**: In a solid, the particles are closely packed together and vibrate in place. They have low kinetic energy compared to liquids and gases. The potential energy is higher because the particles are tightly bonded.
- **Liquids**: In a liquid, the particles have more freedom to move around each other. They have more kinetic energy than in a solid. The potential energy is lower than in solids because the bonds between particles are not as tight.
- **Gases**: In a gas, the particles move very quickly and are far apart from each other. They have high kinetic energy. The potential energy is very low because the particles are barely interacting with each other.

### Examples in Everyday Life

1. **Heating a Pot of Soup**: When you heat soup, you're adding energy to the liquid. The particles in the soup move faster, increasing the internal energy. This makes the soup hotter.
2. **Melting Ice Cream**: When ice cream melts, it changes from a solid to a liquid. The particles in the ice cream gain kinetic energy and start to move more freely, increasing the internal energy.

3. **Inflating a Balloon**: When you blow up a balloon, the air inside is a gas. The particles in the air are moving very fast and have high kinetic energy. This high internal energy keeps the balloon inflated.

**Why is Internal Energy Important?**

Understanding internal energy helps us explain why things happen in the world around us. It helps us understand how heat is transferred, why substances change state, and how we can use energy to do work. Scientists and engineers use this knowledge to design everything from refrigerators to rockets.

So, next time you feel the warmth of the sun or see ice melting, remember that it's all about the internal energy of the particles inside those materials. This invisible energy plays a huge role in making the world work the way it does!

Independent practice

**Comprehension Questions**

1. What are the two main types of energy that make up internal energy in materials?
2. How does the internal energy of particles in a solid compare to those in a gas?
3. Explain how heating a pot of soup affects the internal energy of the soup.
4. Describe what happens to the particles in ice cream when it melts.
5. Why is understanding internal energy important for scientists and engineers?

**Understanding Questions**

1. What happens to the kinetic energy of particles in a material as its temperature increases?
2. How does the arrangement of particles differ between a solid and a liquid?
3. Why do gases have higher kinetic energy compared to solids and liquids?
4. Can you give an example of how internal energy is involved in an everyday activity?

**Correct the Mistake Questions**

1. "In a solid, the particles move freely and have high kinetic energy." Correct this statement.
2. "When water freezes, the internal energy of the water particles increases." Correct this statement.
3. "Potential energy in a gas is higher than in a solid because the particles are more tightly bonded." Correct this statement.

# L5 Comparing energy transfers

**Understanding Energy Units with Heating and Cooling Examples**

Energy is like the fuel that powers everything we do, from running and jumping to heating our homes and cooling our drinks. Scientists measure energy in units called Joules (J), kilojoules (kJ), and kilowatt-hours (kWh). Let's learn about each one and how they relate to heating and cooling!

Joules (J)

1 Joule is a tiny amount of energy. Think about holding a small piece of ice in your hand until it starts to melt. That takes about 1 Joule of energy to begin melting a very small piece of ice.

Kilojoules (kJ)

1 kilojoule equals 1,000 Joules. If you melt a small ice cube (about 10 grams), it takes about 3.34 kJ of energy. So, 1 kJ = 1,000 J.

Kilowatt-Hours (kWh)

A kilowatt-hour is a bigger unit of energy we often see on our electricity bills. It's the amount of energy in kilowatts an appliance transfer in 1hr. For example, if you use a 1,000-watt heater for one hour, you use 1 kWh of energy.

**Comparing Energy Units with Heating and Cooling**

Now, let's compare these units by looking at some heating and cooling activities and how much energy they use.

1. Boiling a Kettle
    - Boiling a kettle with 1 litre of water uses about 100,000 Joules (100 kJ).
    - That's like melting about 30 small ice cubes!
2. Running an Air Conditioner
    - A small air conditioner running for one hour might use about 0.5 kWh.
    - In Joules, this is 0.5 x 3,600,000 (since 1 kWh = 3,600,000 J) = 1,800,000 Joules (1,800 kJ).
3. Using a Hair Dryer
    - If you use a 1,500-watt hair dryer for 10 minutes, it uses 0.25 kWh.
    - In Joules, this is 0.25 x 3,600,000 = 900,000 Joules (900 kJ).
4. Refrigerating Food
    - A refrigerator might use about 1 kWh per day to keep food cool.
    - In Joules, this is 1 x 3,600,000 = 3,600,000 Joules (3,600 kJ).

**Visualizing the Energy**

Let's put it into perspective:

- 100 kJ (boiling a kettle): A burst of energy to heat water quickly.
- 1,800 kJ (running an air conditioner for an hour): A lot of energy to cool a room for a short time.
- 900 kJ (using a hair dryer for 10 minutes): A large amount of energy for a quick burst of hot air.
- 3,600 kJ (refrigerating food for a day): A steady, continuous use of energy to keep food cool all day.

Converting Between Units

1. From Joules to Kilojoules: Divide by 1,000.
    - Example: 5,000 J = 5,000 / 1,000 = 5 kJ
2. From Kilojoules to Joules: Multiply by 1,000.
    - Example: 3 kJ = 3 x 1,000 = 3,000 J
3. From Kilowatt-Hours to Joules: Multiply by 3,600,000.
    - Example: 0.5 kWh = 0.5 x 3,600,000 = 1,800,000 J
4. From Joules to Kilowatt-Hours: Divide by 3,600,000.
    - Example: 7,200,000 J = 7,200,000 / 3,600,000 = 2 kWh

**Summary**

- Joules are like the pennies of energy.
- Kilojoules are like the £10 notes of energy.
- Kilowatt-hours are the big amounts we use to measure household energy use.

Understanding these units helps us see how much energy different heating and cooling activities need and how we use energy in our daily lives. By learning to compare and convert these units, we get a better grasp of the energy around us!

Independent practice

**Comprehension Questions**

1. What unit of energy is used to measure small amounts, like lifting an apple?
2. How many Joules are in one kilojoule (kJ)?
3. How much energy does a 1,000-watt appliance use in one hour?
4. If you run a small air conditioner for one hour, approximately how many kilojoules does it use?
5. What is a common unit of energy you might see on your electricity bill?

**Understanding Questions**

1. Explain how Joules, kilojoules, and kilowatt-hours are related to each other.
2. Why might we use kilowatt-hours instead of Joules to measure household energy use?
3. Describe a situation where you might use a kilojoule to measure energy.
4. How do you convert from kilowatt-hours to Joules?
5. Give an example of an activity that uses about 100 kilojoules of energy.
6. Why is it helpful to understand different units of energy when comparing heating and cooling activities?

**Sentence Completion Questions**

1. Running a microwave for 15 minutes uses a lot of energy, but...
2. A refrigerator uses about 1 kWh per day to keep food cool because...
3. We use kilowatt-hours to measure household energy use because...
4. Boiling a kettle uses about 100,000 Joules, and...
5. Charging a phone might use about 10,000 Joules, but...
6. Air conditioners can use a lot of energy, and...
7. You might see kilowatt-hours on your electricity bill because...
8. Melting a small ice cube takes about 3.34 kJ, but...
9. Using a hair dryer for 10 minutes uses 0.25 kWh of energy because...

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