Heat and Temperature Ch.-09

By the end of this chapter we will be able to-

• Describe solids, liquids and gases in terms of atoms and molecules.
• Use the concept of temperature and the relation of temperature to the average kinetic energy of molecules.
• the connections and the differences between the basic concepts of temperature and heat.
• to explain the process of heat transportation
• to measure the temperature precisely using thermometer.
• to make relationship between Fahrenheit scale and Celsius scale.
• to convert temperature mathematically.
• to explain the pressure of air and humidity.
• to analyze the effect of change of temperature over the pressure and humidity of air.
• to explain the thermal expansion of substance
• to explain the transfer of heat which causes different incidents all around.

What is Heat?

Heat: Heat is a form/kind of energy that is transferred (in the form of wave) from one object to another as a result of a difference in temperature and for which any object becomes hot or cold. P-100

YOU MUST KNOW:

►Heat is a kind of energy by which we feel hot or cold (We feel anything hot or cold due to heat).
►Anything hot or cold is the cause of heat.
► An object becomes hot when it absorbs heat and becomes cold when it releases heat.
►Heat always flows in three processes from a substance at a higher temperature to the substance at a lower temperature.
►Heat can only be felt with the skin out of five senses.
►The glass of hot water feels hot. On the other hand the glass of ice water feels cold.
► How much cold and hot we feel can be expressed by temperature.
►The pressure of air and humidity changes when heat is applied or heat is removed as a result of changes to the temperature.

You know all things in the universe are divided into two.

Matter	Energy
Matter which has weight or mass, occupies place and resists while force is applied.	Energy has no weight, does not occupy place and does not resist while force is applied

We have an intuitive concept of **temperature** as the 'coldness' or 'hotness' of a body, but it wasn't until the 19th century that one of the greatest discoveries in physics related the concept of temperature to the random motion of molecules.
Since temperature is proportional to the average kinetic energy, the temperature must be zero when the kinetic energy is zero.

What is Temperature?

Temperature: Temperature of an object is a measure of **how much** hot or cold the object is. Thus temperature expresses the **thermal condition** of anything.

When the glass is too hot, the temperature is high. When the glass is cold, the temperature is low.

►When two bodies that are in thermal contact and have different temperatures will have a **thermal interaction.**

So when a glass of cold water is placed in a warm room, **heat** flows from the room into the colder water until the temperature of the water becomes equal to that of its surroundings. We say that the colder body has been 'heated'.

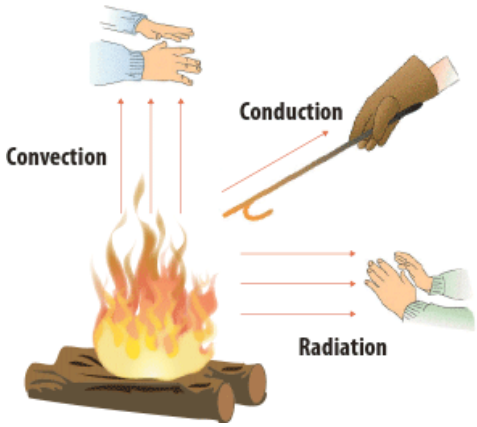
What did you understand the difference between heat and temperature?

Heat	**Temperature**
Heat is a kind of energy Gives us the sensation of hot or cold for anything.	Temperature is the thermal condition of anything. Temperature of an object is a measure of how much hot or cold the object is.

Transmission of heat

The process of heat that transfers from one place to another is known as **heat transmission.** Heat flows from places of higher temperature to places of lower temperature.

Heat flows by the processes-Conduction, Convection and Radiation.



♦Have you ever marked that a steel spoon gets hot when it is kept in a hot curry bowl?

♦How does heat flow away from curry to hand?

Heat flows through the spoon from hot curry bowl by the process of conduction.

Heat flows to solid substances by this process.

Conduction: The process in which heat flows from hot end to cold end without changing the position of the particles rather can vibrate from their own positions is called conduction.

Explanation: We know the particles of solid substances cannot change their positions. They can vibrate from their own positions. Hot particles push adjacent cold particles and they are heated in tum and vibrate rapidly. In this way heat goes from one end to the other.

►Among solid substances, metals such as; Iron, Copper, Brass, Aluminum, Zinc conduct away heat rapidly. So, the utensils made of metals are used to cook.

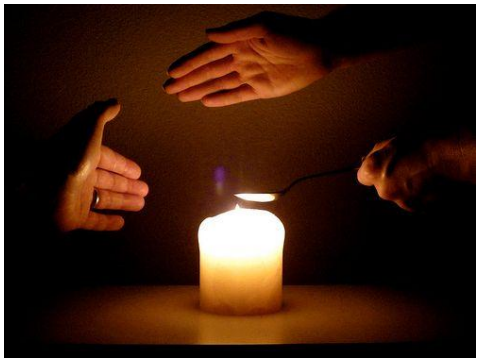
►Heat is conducted away to a minimum by non-metals such as; wood, cotton, cloth, soil etc. That's why; we use a cloth to hold the hot pots.

For this reason, wooden stick is convenient for cooking purpose.

Convection: Heat flows to liquid and gas by this process only.

The process in which heat transfer from one place to another by changing position of liquid or gas particles.

Explanation: Take a pot and put some water and place it on the burner. Then the whole water gets heated. In this case, the particles of water absorb heat and get energy. After getting energy water particles become lighter and goes up. The top particles of cold water goes down and absorb heat. Thus, all the particles in turns absorb heat and get heated. Then heat transfers from one place to another. Thus, hot water from the bottom carries heat above the cold water which goes downward and gets itself heated and then goes up again. The process continues until all the water is equally heated and attains the same temperature. This process of heat transfer is called convection.



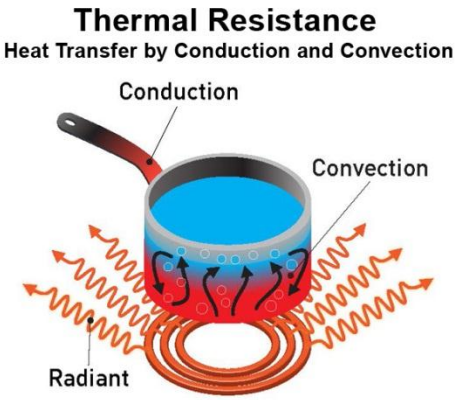
►Have you ever stood by the side of a fire in winter?
The villagers bask by burning woods or twigs during winter. We feel hot while standing by the side of fire. But if you put your hand over the fire carefully, you will feel warmer. Because by the **process of convection the particles** of air get heated and go up but do not go aside. So, we feel hotter over the fire rather than standing aside.

Radiation: The process by which heat energy is emitted by a heated surface in all directions and travels in the form of electromagnetic wave. It does not need a medium unlike conduction and convection. It can take place in a vacuum.
The sun is the main source of heat. The distance between the earth and the sun is open place. There is no gaseous substance.

How does the heat come to the earth from the sun?
Heat comes from the sun through radiation. Heat transfers through radiation where there is **no medium** (non-living body). Heat is a kind of wave which can be transformed from hot place to cold place. Heat transfers or flows in the form of wave during radiation process

Radiator: Some substances radiate heat so easily and they are called radiator. Radiators tend to be cold through radiating heat. Radiators absorb heat as well.
The sun radiates heat. So, we can call it radiator.

Absorber: Some substances that absorb heat and get heated are called absorber.
Liquid water vapors, carbon dioxide, methane, glass, plastics: these substances absorb heat.
In the atmosphere, carbon dioxide, vapour, methane such types of gases act as an absorber of radiated heat which is influencing our life



The earth gets heated by absorbing heat from the sun. The earth may be called an absorber. But å simultaneously the earth is also a radiator. At night, the heated earth radiates heat and gets cold.

Measurement of Temperature:

The name of the instrument used to **measure te**mperature is thermometer.
►Temperature of a human body is **measu**red by means of thermometer.
►Meteorologists use thermometer to **measur**e the temperature of air.
►Constant temperature is kept in industries. That's why in industries they also use thermo**meter to meas**ure the temperature.
But temperature of an object cannot be determined accurately by means of touch. For correct **measu**rement an instrument is used.
Thermometric property: Temperature changes, the volume of liquid increases or decreases. Tempera**ture can be mea**sured by the variation of the volume of liquid. Temperature is measured by using different liquids such as: **mercury, alcohol** etc.

Fixed points:

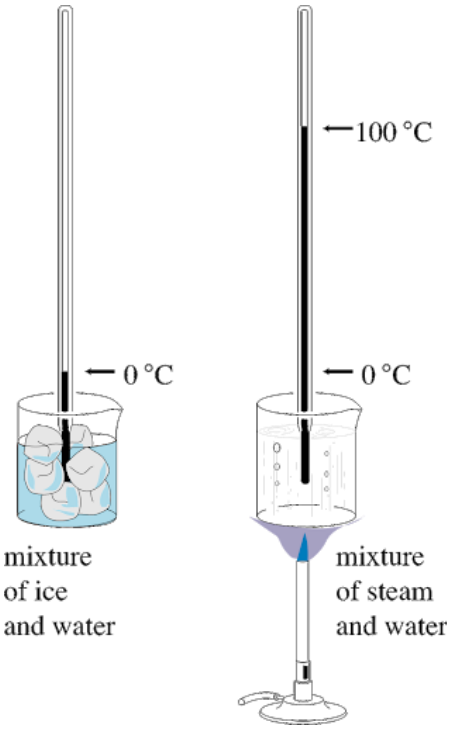
Measuring Scale of Temperature In order to measure anything, the first step is to fix a unit of the thing as a standard for measurement. In measuring temperature, two fixed tempera**tures are considered as** standard. These are known as the fixed points. One is the freezing point and is the boiling point.
The Freezing Point: The temperature at which pure ice melts under normal atmospheric pressure is called the freezing point.
The Boiling Point: The temperature at which pure water boils to vapour under normal atmospheric pressure is called boiling point.
Calibration: The interval between the boiling point and the freezing point is divided into a suitable number of equal divisions.

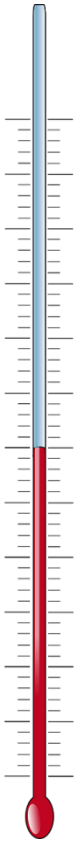
A description of a mercury thermometer is given below:

Mercury thermometer

The type of thermometer that uses mercury as an indicator of temperature is called the mercury thermometer.
It consists of a thick-walled **glass tube** with a narrow and uniform bore. At one end there is a **thin walled bulb**. The other end is kept **open at first**. The bulb is filled with pure and dry mercury through the open end. The rest of the tube does not contain anything except a small amount of mercury vapour. By placing a thermometer in mixture of ice water and allowing the thermometer liquid to reach a stable height, the freezing point mark can be placed upon the thermometer. Similarly, by placing the thermometer in boiling water (at 1 atm of pressure) and allowing the liquid level to reach a stable height, the boiling point mark can be placed upon the thermometer.

The tube is then graduated according to a fixed scale (Celsius or Fahrenheit) for measuring temperature. The bore in the tube of the thermometer is **extremely narrow. So mercury goes upward to a great ext**ent, if the temperature of the bulb slightly increases. How much temperature increases can be understood by observing the mercury level on the scale.
With a calibrated thermometer, accurate measurements can be made of the temperature of any object within the temperature range for which it has been calibrated.





You have certainly seen the thermometer which is used to measure fever. It is mercury thermometer.

The interval which is divided into a suitable number of equal divisions gives us different scales based on it.

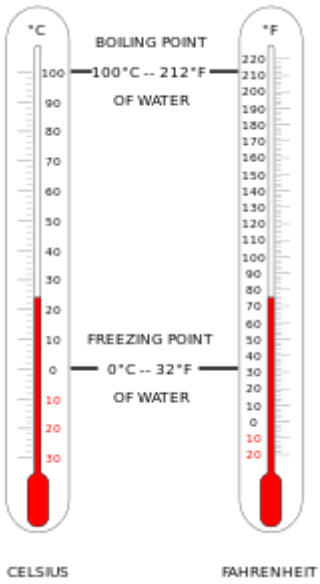
Presently two scales of temperature are followed. Two scales are explained below:

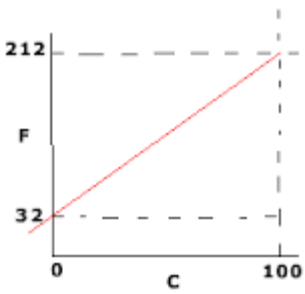
Celsius Scale: The freezing point in this scale is marked 0° and the boiling point is **marked 100°. The interval between two points is divided into 100 equal divisions. Each** division is called one degree Celsius (1 °C).

Scientist Celsius introduced this scale. It was then named Celsius scale after his name. This scale is used for scientific works in different countries of the world including Bangladesh. Such as: you listen to weather forecast that the maximum temperature of the day was 30 degree Celsius. As the interval between the two points is BOILING POINT OF divided into 100 divisions, it is also called centigrade (centi means one hundred and grade means divisions) scale.
[Many other temperature scales exist. In 1742, Anders Celsius (1701– 1744) created the temperature scale that is still commonly used today and is known by his name. On the Celsius scale a value of zero degrees is assigned to the freezing point of water (Figure **3.2**) and a value of 100 degrees is assigned to the boiling point of water.]
Scientist Fahrenheit invented this scale. It is called Fahrenheit Scale after his name.

Fahrenheit Scale: In this scale the freezing point is marked 32 degree (32°) and the boiling point is marked 212 degree (212°). The interval between the two points is divided into 180 equal divisions. Each division is called one degree Fahrenheit (1 °F).

Relation between Celsius and Fahrenheit Scales:





If you know the temperature in Celsius **Scale, it can** easily be transformed into Fahrenheit Scale and vice versa. For this, you have to know an equation.

$$\frac{C}{5} = \frac{F - 32}{9}$$

Where, C= the temperature in Celsius Scale, F= the temperature

Convert the following temperature:

a. 0°C into Fahrenheit

b. 100°C into Fahrenheit

c. 86° F into Celsius

d. 37°C into Fahrenheit

e. 97.6°F into Celsius

f. Low fever, 37.7°C into Fahrenheit

g. Moderate fever, 38.5° into Fahrenheit

h. High fever, 104°F into Celsius

Now let us look at an example. Example: A player of the Bangladesh Cricket Team fell sick while playing in Australia. An Australian doctor measured his temperature and found it 38°C. What was the body temperature of that player in Fahrenheit scale?

Solution:

Expansion of Matter Due to Effect of Heat

Most of the substances expand in volume by the application of heat.

►The expansion is so minor for solid.

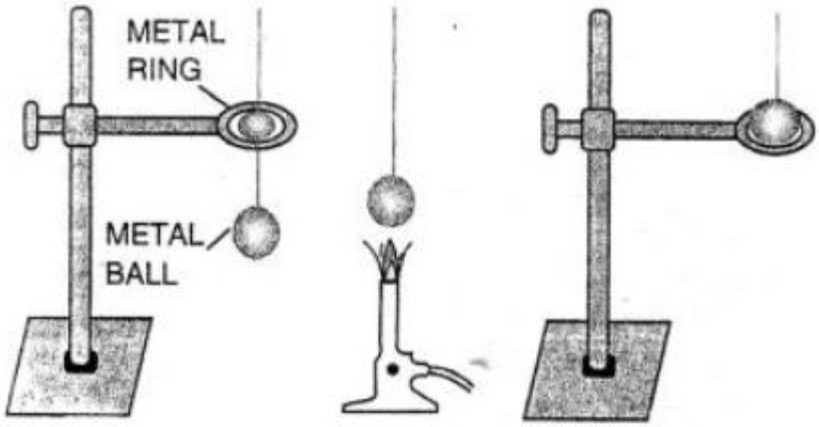
►Most of the liquids do not expand so much by the application of heat.

►But the gaseous substance expands more by the application of heat.

Expansion of solids:

Why is not the brass ball passing through the ring when it is heated?

The reason is that the ball has expanded. The ball has expanded a little due to heat. It proves that most of the solids expand by the application of heat. But this expansion is so minor that we cannot understand easily. Generally metal expands a great by the application of heat in the so**lid matter.**



The Effect of Expansion of Solids in Our Daily Life

We will understand how we make the best use of expansion of solid in our daily life from the examples given below:

1. Have you ever seen that the neck of some glass bottle (which contains jam, sauce) is so tightly fitted that it cannot be opened easily? At this stage generally the metallic neck of the bottle is heated. Then it is opened so easily by twisting.

Why does the neck open so easily then?

Because due to heat the metallic neck expands and it opens easily then.

2. Have you seen rail lines? Why is a gap kept between two consecutive rails of a rail line?

The train runs on the two parallel iron strips. In fact, some gaps are kept between two consecutive rails willingly. The iron rails turn hot when the trains run on it and it is caused due to the friction of wheels with them. As a result the lines increase in length. If there is no gap left between the rails, the line will be twisted. The rails increase and fill us the gap so that the lines do not twist or bend.

Expansion of Liquid: The expansion of liquid is much higher than the expansion of a solid in volume.

Thermometer is made using the expansion of liquid metal mercury. Already you have learnt it. The temperature of the earth is increasing. As a result the **height of the sea surface** is increasing as well for the expansion of the volume of the sea water.

The Effect of Expansion of gas in Our Daily Life: The effect of expansion of gas is formed in nature and in our daily life.

Have you seen baking bread? Why does it swell up?

We know that bread is made with the combination of flour and water. The inside water in the bread turned into vapour. Vapour expands more while heated. As a result, the bread swells. At one stage the bread goes up a great. If we put a hole on the bread, something comes out with a sound.

Engine is driven by the use of expansion of gas due to heat. Fuel burnt heat expands gas which helps drive the engine. Engine is driven by the shocks of the expanded gas. Atmospheric change is found for the expansion of air due to heat.

The Effect of Temperature Over Humidity and Atmospheric Pressure

The particles of air move to and fro in air. They apply force when they are obstructed. As a result, pressure exists in air.

The applied force of air per unit area is called the pressure of air.

►The air exerts pressure at all directions.
►The atmospheric pressure of anywhere depends upon their temperature.
►The atmospheric pressure is increased within a confined pot when the temperature rises.

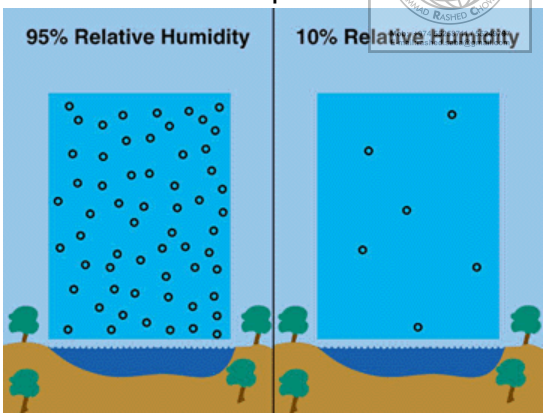
Why does the pressure of atmosphere decrease when temperature increases?

The reason is that the atmosphere is not confined, it is open. **When temperature increases,** air gets lighter and goes up. For this, the density of air decreases and air pressure decreases.

This is why if the temperature of a place increases, then air pressure falls down i.e. **depression takes place**.

High pressure takes place where temperature is low.

Humidity of air: We know that the water of earth's surface turns into vapour and mixes with air. Air contains water vapour more or less all the time. The amount of water vapour in air is expressed as the humidity of air.



If air contains more water vapour, the humidity will be more.
If air contains less water vapour, the humidity will be less.
Sweating of our body takes place when humidity is more in the air,
The water turns into vapour more when temperature increases. On the other hand, air contains more water vapour if temperature increases.

How does rain forms in the month of Srabon and Bhadro?

In our country we feel sultry weather during the month of Srabon and Bhadro. Then by the influence of monsoon a lot of water vapour floats and comes to land from the Bay of Bengal. When water vapour increases too much, at one stage it is condensed and turns into cloud and at last it rains.

ACTIVITIES:

1.Work: First take two glasses. Touch the glasses and see how cold or hot they are. Now pour hot water into one glass and put pieces of ice in another one. Wait for two minutes. Now throw hot water and ice out of the two glasses. Now hold and touch the two glasses by turns. How do you feel of the glasses? One is hot, another is cold. Now you discuss yourself, what does the hot glass contain for which it is hot? Why did the other glass feel cold? What does it have in it or does not have in?
Caution:
►Pour hot water in such a way so that it does not fall on your body.
►Never touch the hot water pot or glass with your bare hand.

2. Let us do another work: Touch a steel glass with your hand. Whether it is hot or cold, keep it in your mind. Now fill the steel glass with hot water. Now touch the glass after two minutes. You will feel that the glass is becoming hotter gradually. Now throw the water out of the glass and touch the glass after a minute. The glass is getting cold.
Caution: Pour hot water in such a way so that it does not fall on your body. Never touch hot water pot or glass with your bare hand. You will not hold the glass which is filled up with hot water for a long time.
Have you found that the hot water glass has got hot gradually? On the other hand, it has got cold when hot water was thrown out. How much cold or hot? To understand it, temperature is used.

3. Expansion of Gases:

Equipment: A glass bottle, two water tubs, hot and cold water, balloon, thread.

Work: Take a strong and empty glass bottle. Tie a balloon with a thread to the neck of the bottle. Take boiling water in one tub and cold water in another tub. Now dip the bottle in hot water cautiously. What do you see? The balloon has blown away a little. Now dip the bottle in cold water. Has the balloon soaked? Why is it happening?

Caution: Be careful in using boiling water.

The gas expands a great while it is heated. If we dip the bottle in hot water, the gas inside of the bottle gets heat and expands. As a result the balloon has blown away after receiving the air from the bottle. If we dip the bottle in cold water, the inside air of the bottle contracts. As a result the air of the balloon comes back into the bottle. That is why the balloon is soaking.

It proves that the gaseous substances expand due to heat.

LET'S CHECK OUR LEARNING:

Fill in the gaps

1. Heat flows through liquid and gas by the process of ……..

2. The temperature which boils pure water and turns into vapour in normal pressure, is called the…

3. The freezing point of Celsius Scale is ___ degree Celsius.

4. The freezing point of Fahrenheit Scale is _degree Fahrenheit.

5. The boiling point of Celsius Scale is ___ degree Celsius.

6. The boiling point of Fahrenheit Scale is _degree Fahrenheit.

7……of air decreases when the amount of vapour is less.

8……of air decreases when the amount of vapour is less.

Short answered questions:

1. Give three example of a well absorber of atmosphere?

2. What are the Characteristic of temperature?

3. What are the Characteristic of heat?

4. What are the differences between heat and temperature?

5. Why is a gap kept between two consecutive rails of a rail line?

6. We feel warm by the side of a fire. We feel warmer or hot if we keep our hand over fire. Why does that happen?

7. Why do we not hold cooking hot pot with bare hand? Why do we use a piece of cloth?

8. Why does the pressure of atmosphere decrease when temperature increases?

9. Why does the pressure of atmosphere increase when temperature decrease?

10.

Creative questions 1.

Rakin reads in class seven, One evening she feels feverish. The temperature measured in Celsius Scale is 98°F. Sharmin can understand Centigrade Scale temperature instead of Fahrenheit Scale. Being anxious she goes to a doctor to measure the temperature. The doctor measuring thermometer and finds no fever.

a. What is humidity?

b. Explain the advantage of less humidity.

c. What was the temperature in Centigrade Scale at Sharmin's body?

d. Explain with reason whether Sharmin would go to the doctor if she knew the relation between Fahrenheit and Centigrade Scale.

2. Sara observes daily activities that happen in his life very carefully. One day he saw that the lid of the cooking pot fell down due to heat. On the other hand she noticed some gaps in their door in winter season where he found no gap in the summer. Both the incidents made her thoughtful.

a. Which matter expands more due to heat?

b. Why is a gap kept between two consecutive rails of a rail line?

c. Explain the cause of incidents which Sara observed while cooking was going on.

d. Analyze the cause of the two behavior of wooden door which Sara observed during winter and summer season.

S.

Internal energy is the total random kinetic energy of the particles of a substance, plus the total inter-particle potential energy of the particles.

Change of phase

When heat is provided to a body or removed from it, the body may not necessarily change its temperature. The body may change **phase** instead.

Changes of phase happen at constant temperature (Figure **3.5**) and include:

- **melting** – when a solid changes to a liquid (heat must be provided to the solid)
- **freezing** – when a liquid changes into a solid (heat must be taken out of the liquid)
- **Vaporization** (or **boiling**) – when a liquid changes into vapour (by giving heat to the liquid)
- **Condensation** – when a vapour changes into a liquid (by taking heat out of the vapour).

Why does the heat absorbed or removed not result in a temperature change?

The particle model of matter

As we look closer and closer into matter we discover smaller and smaller **structures**. We find that compounds are made out of molecules, molecules are made out of atoms and atoms contain nuclei and electrons. Nuclei, in turn, contain protons and neutrons.
In thermal physics we are mostly interested in molecules, atoms and electrons.
[Now, all substances consist of particles and, whether in the solid, liquid or gas phase, the particles are in constant motion. They therefore have kinetic energy.
In a gas, the particles move randomly throughout the entire volume of the gas.
In a solid the motion of the particles is on a very much smaller scale – the particles simply vibrate about their equilibrium positions. But this also requires kinetic energy.]

In a solid there are forces between the particles that can be **modeled** by springs joining neighbouring particles (Figure **3.1**). The springs then represent the **bonds** between the particles.	In liquids the forces between the particles are weaker. The particles are able to move around the volume of the liquid and the liquid will take the shape of the container in which it is placed. However, the inter-particle forces between the particles in a liquid are sufficiently strong that the particles cannot move far from each other.	In gases the inter-particle forces are very weak so as to be almost negligible. The only time significant forces exist between the particles is during collisions.

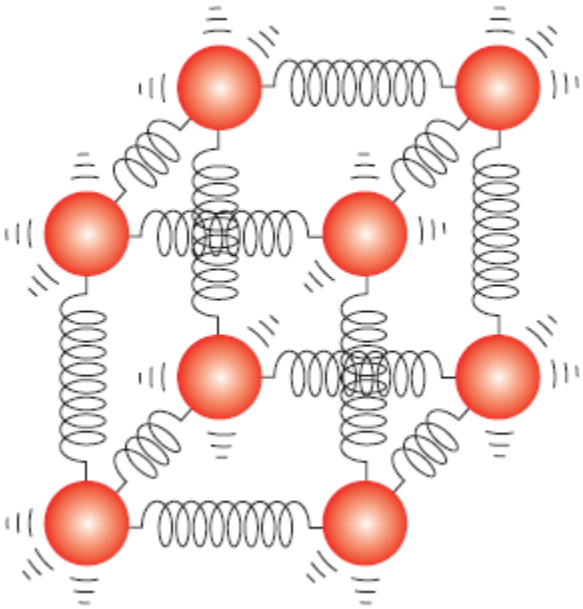


Figure 3.1 Particles in the solid phase oscillate about fixed positions but are not free to move inside the solid.