INTRODUCTION TO PARTICLES & HEAT

ALL ABOUT PARTICLES

When you warm up an ice cube it melts. When you walk past a coffee shop you can smell the coffee outside the shop. When you get out of a swimming pool you feel cold, even if it is a warm day.

All these things can be explained by a theory called the particle theory (also called kinetic theory). This theory says that matter is made up of tiny particles that move all the time. These particles are atoms or molecules.

It is very hard to imagine just how small they are, but if you think that there are about 50,000,000,000,000,000,000 particles in a thimbleful of air, you'll have some idea!

The main points of the kinetic theory are:

- All matter is made up of tiny, invisible, moving particles.
- The particles move all the time – the higher the temperature, the faster they move.
- Small particles move faster than heavier particles at the same temperature, because they have the same kinetic energy.
- As the temperature rises, the particles have more kinetic energy and move faster.

DIFFUSION

Have you ever noticed that the smell of food being cooked in the kitchen seems to go all around the house? As the food cooks, particles from the food are released. These spread in the air around the house. This movement of particles is called diffusion. All gases diffuse to fill the space available to them.

An everyday example of diffusion in liquids occurs when milk is added to a cup of hot tea.

Step 1

Step 2

Step 3

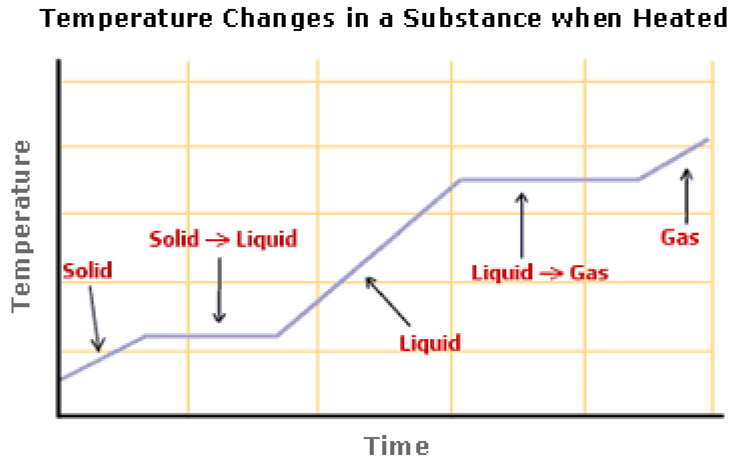
At first, the milk particles are more concentrated at the top of the cup where the milk is poured in, but gradually the particles spread throughout the liquid until the concentration is the same everywhere. This illustrates an important point about diffusion. Diffusion is the movement of particles from a region of higher concentration towards a region of lower concentration.

ENERGY CHANGES

When we add heat to a substance, we give it more energy so the particles move faster. We notice this as a rise in temperature. Heat and temperature are related but they are not the same thing. It is important not to confuse the temperature of an object with the total quantity of heat energy it can give out.

A spoonful of boiling water, for example, has exactly the same temperature as a saucepan of boiling water, but you would get far less thermal energy from it if you tipped it over yourself.

During a change of phase, the temperature remains constant. So, if a graph is plotted of temperature versus time for a solid that eventually changes to a liquid and then to a gas, the changes of phase will be very obvious on the graph.



During the change in phase, the heat energy supplied is used to weaken the forces between the particles. Because the energy is not used to increase the kinetic energy of the particles, the temperature remains constant until all the forces between the particles have been weakened.

Movement of Heat

Whenever there is a temperature difference in a material, heat flows to try and balance this difference. There are three ways in which heat energy can travel from a warm region to a cooler one — *conduction*, *convection* and *radiation*.

Conduction

As mentioned earlier, heat energy causes the particles in a substance to vibrate. Conduction happens when this vibration moves from particle to particle as they bump into each other. The heat energy passes from one layer of particles to the next until it reaches the colder end.

In large molecules, such as plastics, where the particles are not able to vibrate easily, heat energy cannot pass on very well. As a result, plastics are poor conductors of heat. Similarly, if the particles in a substance are far apart, the vibrations cannot pass on easily. Liquids and gases are poor conductors of heat as their particles are far apart.

Convection

In fluids, convection is the main way in which heat energy is transferred. When part of a fluid is heated, it expands and gets less dense. As a result, this warmer fluid floats upwards taking the heat energy with it. Colder fluid takes its place underneath and the process is repeated. Convection is used in many domestic hot water systems to circulate hot water around the pipes.

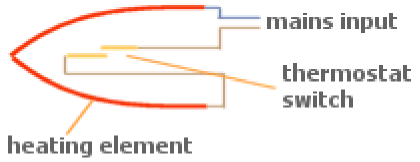
Radiation

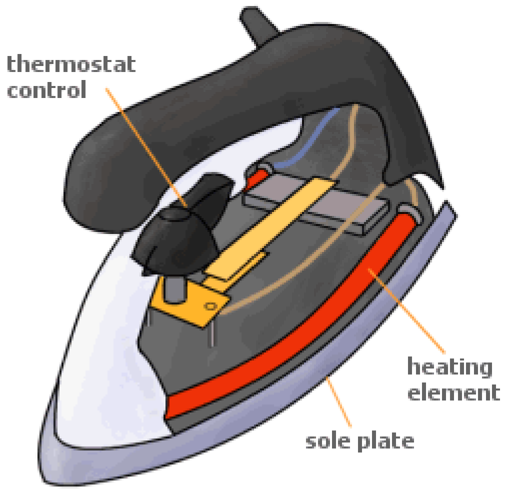
All hot objects radiate heat to their surroundings through electromagnetic waves. These waves are easily absorbed and their energy becomes heat energy. The wavelengths are too long for us to see with our eyes, but they do get shorter as the temperature increases and so hot objects do, eventually, emit some waves that we can see. Think of a cooker ring that glows 'red hot'. Radiated heat can travel in a vacuum as it does not need particles to move.

Expansion and Contraction

As mentioned before, adding heat to a substance causes the particles to vibrate more and thus move further apart. Generally speaking, solids don't expand very much. However, when they do, the forces can be very large. Think of a large bridge – bridges have gaps in them to allow for expansion and contraction in very hot or cold weather. The force exerted during expansion would be enough to collapse the bridge if the gaps were not there.

An everyday use of expansion can be found in a simple thermostat. A simple thermostat contains a bimetallic strip. A bimetallic strip consists of two strips of metal fastened together. When the bimetallic strip is warmed, one metal expands more than the other causing the strip to bend and break contact from the source of energy. As it cools down, it makes contact again. It then warms up again, bends away again, breaks contact again, and so on.





Thermostat in an iron

Liquids expand more than solids when heated as their particles are further apart. An everyday use of the expansion of liquids can be seen in a thermometer. The liquid inside expands along the bore of the glass tube reaching different points along the scale as the temperature rises.

Gases expand the most when heated. The expansion of air when heated and its contraction in the cold was known as early as the third century B.C. However, the Italian scientist, Galileo, was one of the earliest scientists to recognise that this property could be used to measure relative degrees of heating. He is credited with inventing the thermometer around 1593.