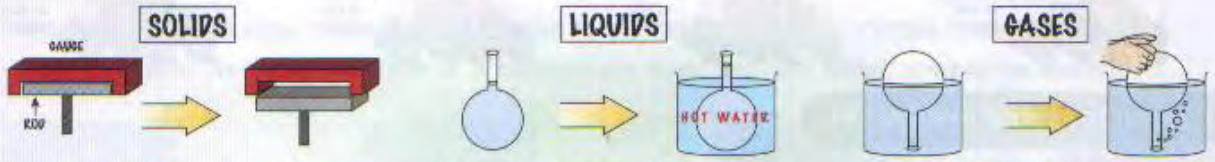
All materials exist as either a SOLID, LIQUID or GAS.
If a material takes in or gives out heat energy it will either **EXPAND** or **CONTRACT.**
If there is a great enough transfer of heat energy a **CHANGE OF STATE** takes place.

EXPANSION AND CONTRACTION

A material **EXPANDS** (takes up more space) when it is heated. The heat energy taken in causes the particles which make up the material to increase their movement causing them to move further apart.
This REDUCES the DENSITY of the material since the SAME MASS of material now occupies a GREATER VOLUME.
Here are three simple demonstrations.



On heating the solid rod expands and it no longer fits into the gauge.

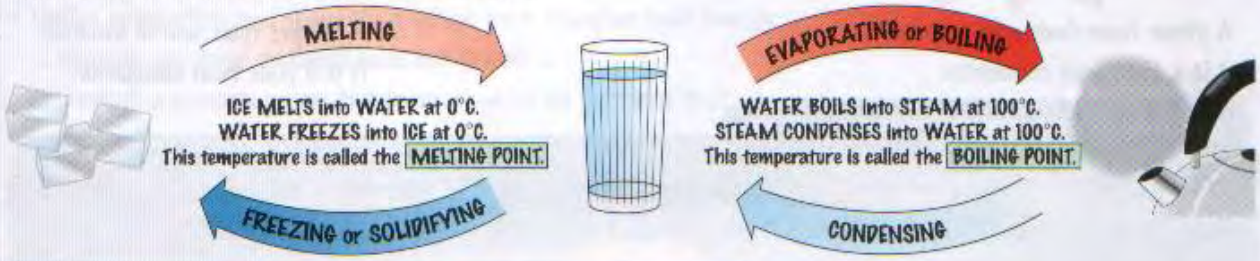
The liquid inside the flask expands when the flask is put in a container of hot water.

The gas inside the flask expands when it is heated by the warmth of the hands.

Also, a material **CONTRACTS,** takes up less space when it is cooled down. This INCREASES the DENSITY of the material.

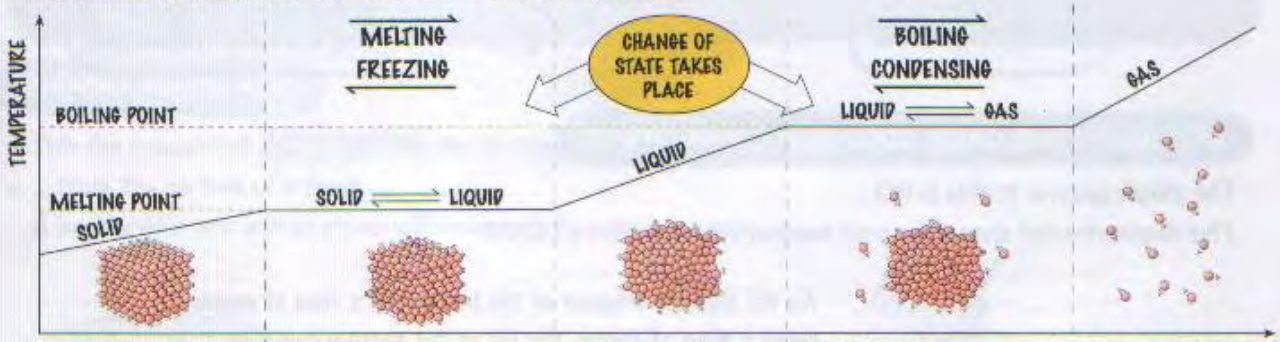
CHANGE OF STATE

A change of state occurs if a material is heated up or cooled down so that it changes from one state to another e.g. solid to liquid, liquid to gas. A change of state always takes place at a FIXED TEMPERATURE for a particular material. If we think of ice, water and steam ...



USING THE PARTICLE MODEL TO EXPLAIN CHANGE OF STATE

Below is a typical graph of how the temperature of a material would change against time if the material was being heated. To begin with the material is in a SOLID STATE.



As the solid is heated the particles vibrate more and more.

The SOLID MELTS. The particles break away and begin to move around. This occurs at a fixed temperature called the MELTING POINT.

As the liquid is heated the particles move around faster and faster.

The LIQUID BOILS. The particles begin to escape from the surface of the liquid. This occurs at a fixed temperature called the BOILING POINT.

As the gas is heated the particles move around even faster.

Since changes of state are reversible if we were to start off with a GAS and then COOL IT DOWN we would get a graph which is a mirror image of the one above.

KEYWORDS

Match the keywords from this unit to their definitions ...

TEMPERATURE	A unit of temperature.
THERMOMETER	A material that allows very little heat energy to flow through it.
DEGREES CELSIUS	Transfer of heat energy through the movement of particles.
HEAT ENERGY	A measure of how hot something is.
EXPANSION	When a material changes from a solid to a liquid or a liquid to a gas etc.
CONTRACTION	A material that allows heat energy to flow through it easily.
CHANGE OF STATE	If something takes this in or gives it out its temperature changes.
THERMAL CONDUCTOR	Used to measure the temperature of something.
THERMAL INSULATOR	Transfer of heat energy by waves.
CONDUCTION	Transfer of heat energy through a substance without any movement of the substance itself.
CONVECTION	Transfer of heat energy due to the loss of particles from the surface of a liquid.
RADIATION	This is the result of a material's temperature being increased.
EVAPORATION	This is the result of a material's temperature being decreased.

HISTORY OF THE THERMOMETER

In the late 1500's Galileo Galilei created a very crude air thermometer, which enclosed air and water in a tube. The theory behind this was that a rise in temperature warmed the air so that it expanded and thus pushed the water level up. This was, however, a grossly inaccurate method because air pressure also changes the water level. In 1594, Sanctorius measured body temperature by placing the air thermometer in patient's mouths, thus leading to today's clinical thermometers. The next major progression, almost 100 years later, came from Guillame Amontons, when he replaced the water in the thermometer with mercury. Today, the two most common thermometers are the liquid-in-glass and the clinical types. Both consist of liquid, usually mercury or coloured ethanol and a calibrated capillary tube. There are two main differences between these thermometers; firstly the temperature range of a clinical thermometer is approximately 35°C to 45°C with very small graduations, the scale and graduations are considerably larger on a liquid-in-glass thermometer; secondly the capillary tube of a clinical thermometer has a kink in it or constriction near the bulb.

1. How did the crude air thermometer work?
2. Why was this an inaccurate method of measuring temperature?
3. Why do you think it would be important for a coloured liquid to be used in the thermometer?
4. Can you think of a reason why clinical thermometers have a smaller temperature range?
5. Why does a clinical thermometer have a constriction in the capillary tube?

TRANSFER OF HEAT

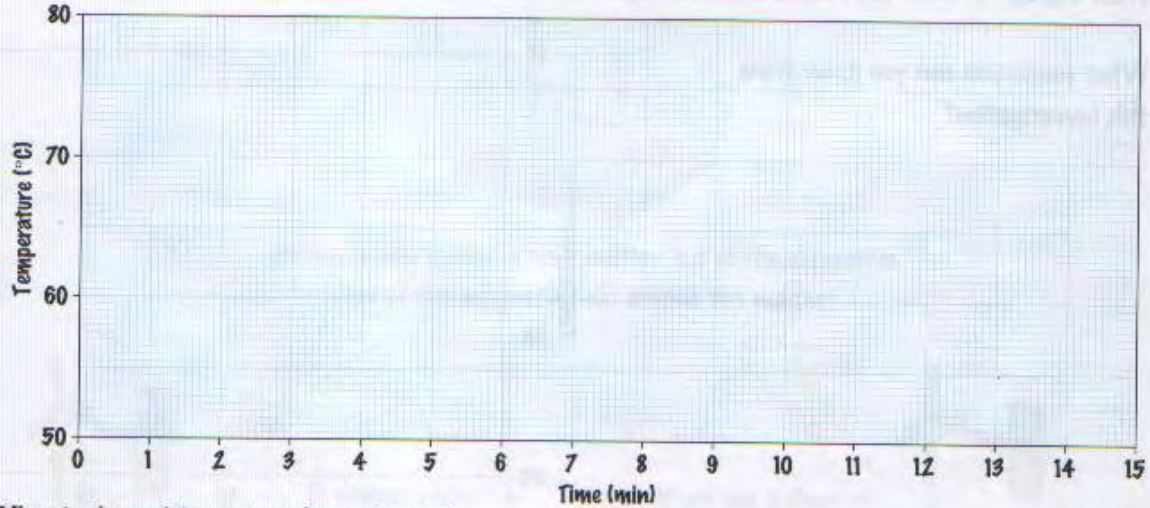
Temperature is a measure of how ..... something is. A ..... can be used to measure temperature in ..... celsius. If an object takes in heat energy then its temperature ..... and it now takes up more space i.e. it ..... . The opposite happens if it gives out heat energy. If there is a big enough transfer of heat then a ..... of ..... takes place. This takes place at ..... temperatures called the ..... point and the ..... point. Heat energy can be transferred in four ways: ..... , ... , ... and ..... . A material that allows heat energy to flow through it is called a thermal ..... , otherwise it is a thermal ..... .

COOLING CURVE

A test tube containing stearic acid was placed in a water bath until its temperature reached 80°C. The test tube was then taken out and the temperature of the stearic acid was taken at 1 minute intervals for 15 minutes. The results were as follows.

TEMPERATURE (°C)	80	77	74	72	70	69	68	68	68	68	68	67	66	63	60	57
TIME (min)	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15

1. Plot a graph of the results.



2. What is the melting point of stearic acid?

.....

3. Use the particle theory to explain what happens at this temperature.

.....

.....

.....