Expansion of solids, liquids and gases

Thermal expansion is the tendency of matter to change its shape, area, volume, in response to a change in temperature. When a substance is heated, molecules begin to vibrate and move more, usually creating more distance between themselves. Substances which contract with increasing temperature are unusual, and only occur within limited temperature ranges.

The **coefficient of thermal expansion** describes how the size of an object changes with a change in temperature. Specifically, it measures the fractional change in size per degree change in temperature at a constant pressure, such that lower coefficients describe lower propensity for change in size. Several types of coefficients have been developed: volumetric, area, and linear.

Linear expansion means change in one dimension (length) the change in length measurements of an object due to thermal expansion is related to temperature change by a coefficient of linear thermal expansion.

$\Delta l = \alpha \, l \, c \, \Delta T$

Area expansion

The area thermal expansion coefficient relates the change in a material's area dimensions to a change in temperature.

$Ah = Ac(1 + 2\alpha\Delta T$

Volume expansion of solids We now need to consider the expansion of a solid in three dimensions, where the length, breadth and height of the substance all increase on heating.

$V\,h = Vc(1 + 3\alpha\Delta T)$

Expansion in liquids

liquids have no definite shape and they take the shape of the container. Consequently, liquids have no definite length and area, so linear and areal expansions of liquids. The expansion of liquids is usually measured in a container. When a liquid expands in a vessel, the vessel expands along with the liquid. Hence the observed increase in volume (as measured by the liquid level) is not the actual increase in its volume. The expansion of the liquid relative to the container is called its *apparent expansion*, while the actual expansion of the liquid is called *real expansion* or *absolute expansion*.

Quantity of heat, specific heat capacity and heat capacity

One calorie is the quantity of heat energy required to increase the temperature of 1 g of water by 1 °C. The amount of energy in joules required to increase the temperature of 1 g of water by 1 °C is 4.18 J and so: 1 cal = 4.2 J

the amount of heat energy required would depend on three things:
1. The substance being heated.
2. The mass of the substance. The greater the mass of the substance, the more heat energy will be required to raise its temperature.
3. The temperature rise required.

Each substance has a specific heat capacity (c), which is defined as: The heat energy required to raise the temperature of 1 kg of a given substance by 1 K.

specific heat capacity, the quantity heat energy required (Q) to increase the temperature of a substance is found using the equation below:

$c = Q/ m\Delta T$ This is usually written as: $Q= mc\Delta T$

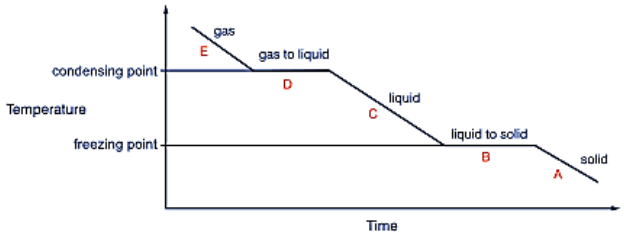
m = mass of substance (kg) c = specific capacity of substance (J/kg K)

The heat energy lost from the hot body will equal the heat gained by the cold body. Heat energy lost by hotter body = heat energy gained by colder body

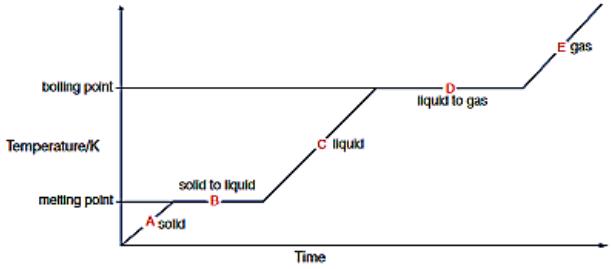
A calorimeter is used in specific heat capacity and heat capacity experiments

Changes of state

Heating curves show how the temperature changes as a substance is heated up. Cooling curves are the opposite. They show how the temperature changes as a substance is cooled down.



A cooling curve for a gas cooling to eventually become a solid.



This graph shows how the temperature of water changes as it is continuously heated.

cooling curve a graph showing the temperature of a substance against time as it loses heat energy and changes state heating curve a graph showing the temperature of a substance against time as heat energy is applied and it changes state melted when a substance has changed from a solid to a liquid state phase the distinct form of a substance under different conditions e.g. solid, liquid, gas

latent heat, energy absorbed or released by a substance during a change in its physical state (phase) that occurs without changing its temperature. The latent heat associated with melting a solid or freezing a liquid is called the heat of fusion; that associated with vaporizing a liquid or a solid or condensing a vapour is called the heat of vaporization.

the latent heat for a given mass of a substance is calculated by $Q= mL$