Properties of Matter

Heat

Summary

Heat is a form of energy that is measured in **joules** (J).

The **temperature** of an object is a measure of the average kinetic energy of the particles in the object and is measured in **degrees Celsius** (°C).

Heat moves from regions of high temperature to regions of low temperature by three processes:

Conduction - In conduction the vibration (kinetic energy) of hot particles is passed from one particle to the next.
Conduction takes place in solids.

Convection - Cold fluids are more dense than hot fluids and so they fall, whilst the hot fluids rise, setting up *convection current*.
Convection takes place in liquids and gases.

Radiation - Heat radiation is energy in the form of electromagnetic rays (infrared rays).
Radiation is the only method of heat transfer in a vacuum.

The rate of heat loss depends on the temperature difference between the two objects.

Heat loss from the can be reduced in the following ways:

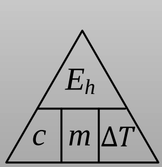
- Having a gap between two surfaces (e.g. double glazing or the walls of a vacuum flask) reduces heat loss by conduction.
- Insulation (e.g. polystyrene foam or fibreglass wool) traps a layer of air around an object and so reduces heat loss by convection.
- Placing a lid on a container reduces heat loss by convection.
- Silver surfaces (e.g. on a vacuum flask) reduce heat loss by radiation.

Energy, Mass, Temperature Change and Specific Heat Capacity

$$\text{energy} = \text{specific heat capacity} \times \text{mass} \times \text{temperature change}$$

J = J kg^{-1} °C^{-1} × kg × °C

$$E_h = cm\Delta T$$



$$c = \frac{E_h}{m\Delta T}$$

$$m = \frac{E_h}{c\Delta T}$$

$$\Delta T = \frac{E_h}{cm}$$

The same mass of different materials requires different quantities of energy to raise the temperature of the material by one degree Celsius.

The quantity of heat energy required to raise the temperature of 1 kg of a material by 1 °C is called the **specific heat capacity**, c, of a material.

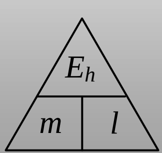
Specific heat capacity has the unit joules per kilogram per degree Celsius (J kg^{-1} °C^{-1}). For example water has a specific heat capacity of 4 180 J kg^{-1} °C^{-1}.

Specific Latent Heat

$$\text{heat energy} = \text{mass} \times \text{specific latent heat}$$

J = kg × J kg^{-1}

$$E_h = ml$$



$$m = \frac{E_h}{l}$$

$$l = \frac{E_h}{m}$$

The heat energy required to change the state of one kilogram of a substance is known as its **specific latent heat**.

Specific latent heat is measured in joules per kilogram (J kg^{-1}).

When a substance change state from a solid to a liquid or a liquid to a gas latent heat is absorbed (taken in).

When a substance changes state from a gas to a liquid or a liquid to a solid latent heat is released (given out).

Specific latent heat of fusion is the amount of heat energy required to change one kilogram of a substance from a solid at its melting point to a liquid at the same temperature

Specific latent heat of vaporisation is the amount of heat energy required to change one kilogram of a substance from a liquid at its boiling point to a gas at the same temperature.

During a change of state there is no change in temperature.

Properties of Matter

Gas Laws & The Kinetic Model

Summary

The pressure, temperature and volume of gases are related to each other by the **gas laws**.

Pressure is a measure of the force per unit area exerted on a surface.

Pressure is measured in pascals (Pa) or newtons per square metre (N m^{-2}).

1 Pa = 1 N m^{-2}.

Pressure can be reduced by spreading the force out over a large area (e.g. snowshoes and tractor tyres).

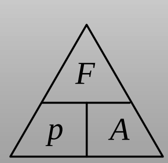
Pressure can be increased by exerting a force on a small area (e.g. the blade of a knife or the point of a nail).

The pressure of a gas is due to the force exerted by the particles of the gas when they collide with the walls of the container.

Pressure, Force & Area

$$pressure = \frac{force}{area}$$

Pa (pressure), N (force), m^2 (area)



$$p = \frac{F}{A}$$

$$F = pA$$

$$A = \frac{F}{p}$$

The **temperature** of a gas is a measure of the average kinetic energy of the particles in a gas.

The lowest possible temperature, the temperature at which all particle motion stops, is known as **absolute zero**.

On the **Celsius** temperature scale absolute zero is -273 °C.

On the **kelvin** temperature scale absolute zero is 0 K.

NOTE: To convert temperatures from Celsius to kelvin, add 273.

To convert temperatures from kelvin to Celsius, subtract 273.

A change in temperature of 1 °C is the same as a change of 1 K.

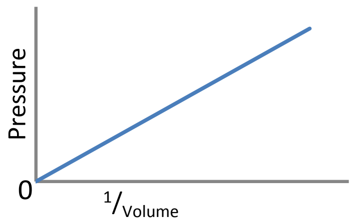
Gases expand to fill the container they are in, so the **volume** of a gas is the same as the volume of the container the gas is in.

Pressure and Volume **(Boyle's Law)**

The pressure of a fixed mass of gas is inversely proportional to the volume of the gas, provided the temperature of the gas remains constant.

$$p \propto \frac{1}{V}$$

$$p_1V_1 = p_2V_2$$

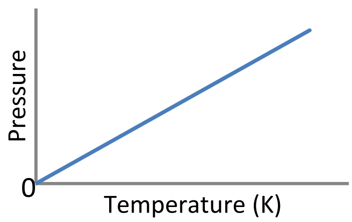


Pressure and Temperature **(Gay-Lussac's Law)**

The pressure of a fixed mass of gas is directly proportional its kelvin temperature, provided the volume of the gas remains constant.

$$p \propto T$$

$$\frac{p_1}{T_1} = \frac{p_2}{T_2}$$

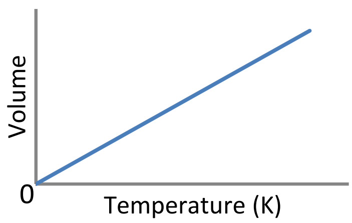


Volume and Temperature **(Charles' Law)**

The volume of a fixed mass of gas is directly proportional its kelvin temperature, provided the pressure of the gas remains constant.

$$V \propto T$$

$$\frac{V_1}{T_1} = \frac{V_2}{T_2}$$



The three gas laws can be combined into a **general gas equation**:

$$\frac{p_1V_1}{T_1} = \frac{p_2V_2}{T_2}$$

The relationships between pressure, temperature and volume can be explained by **kinetic theory**. In kinetic theory it is assumed that all the particles in a gas are in constant random motion and do not lose energy when they collide with each other or the walls of the container.

Pressure and Volume
(Boyle's Law)

- decrease the volume of the gas
- particles collide with walls of container more often, but with the same individual force
- total force on container walls increases
- area of walls decreases
- pressure increases

Pressure and Temperature
(Gay-Lussac's Law)

- increase the temperature of the gas
- kinetic energy, and speed, of gas particles increases
- particles collide with walls of container more often and with a greater individual force
- total force on container walls increases
- area of walls is the same
- pressure increases

Volume and Temperature
(Charles' Law)

- increase the temperature of the gas
- kinetic energy, and speed, of gas particles increases
- particles collide with walls of container more often and with a greater individual force
- total force on container walls increases
- for pressure to remain constant the area of the walls must increase
- volume increases