

Chapter 15: Quantity of Heat and Heat Transfer

States of matter include Solids, Liquids and Gases.

Def: Heat is a form of energy that can cause a rise in temperature when added or a fall in temperature when withdrawn.

Def: The Heat Capacity (C) of an object is the heat energy needed to change its temperature by 1 K (1 °C)

Formula:

Heat = Heat Capacity x Change in Temperature

$$Q = C\Delta\theta$$

Example:

A beaker of water has a heat capacity of 2500 JK^{-1} . How much heat energy must be added to raise its temperature from $12 \text{ }^{\circ}\text{C}$ to $86 \text{ }^{\circ}\text{C}$.

Specific Heat Capacity (SHC)

Def: The Specific Heat Capacity (c) of a substance is the heat energy needed to change one kilogram of the substance by one Kelvin.

Unit: Joule *per kilogram* per Kelvin ($\text{Jkg}^{-1}/\text{K}^{-1}$).

Formula:

Change in Heat Energy = (Mass)(Specific Heat Capacity)(change in Temperature)

$$Q = mc\Delta\theta$$

Example:

How much heat energy is needed to raise the temperature of 700 g of water from 15 °C to 60 °C.

Example:

150 grams of copper at $100\text{ }^{\circ}\text{C}$ is added to 120 grams of water in a 80 gram copper calorimeter at $20\text{ }^{\circ}\text{C}$. If there is no heat loss to the surroundings, find the final temperature of the system.

Storage Heaters.

- A storage heater consists of an electric heater surrounded by bricks of high specific heat capacity. The bricks are heated by night when electricity is cheap.
- During the day the bricks slowly give out their heat, thus heating the room.
- Because the bricks have a high specific heat capacity they can absorb a lot of heat without increasing very much in temperature, therefore not losing much back to the environment.

Heat Change Without a Change in Temperature.

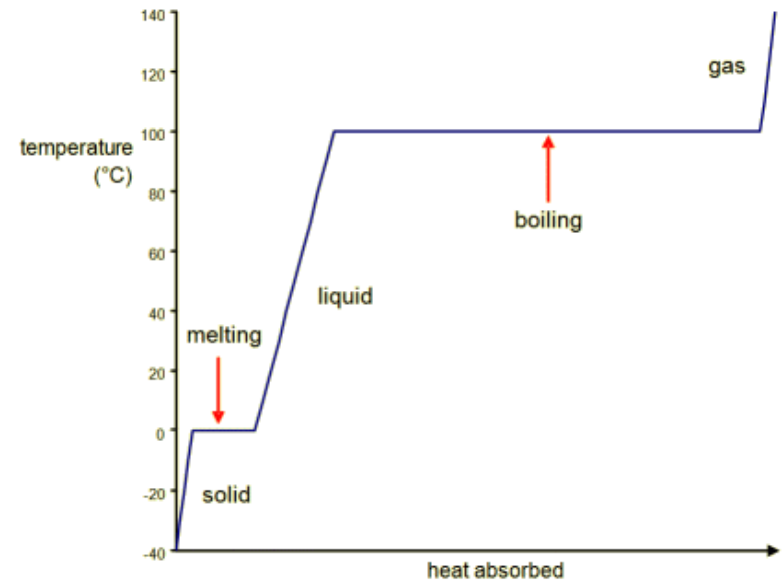
When a substance is changing state, it can take in or give out heat energy without changing temperature.

If you've got a block of ice at $-5\text{ }^{\circ}\text{C}$ and heat it up, you will notice that while it's melting, the melted water will not rise above $0\text{ }^{\circ}\text{C}$ until all the ice has melted. The heat which is being added is not causing a rise in temperature, hence the term 'latent heat' (hidden heat).

Latent Heat

At the melting and boiling points, the energy taken in is used to change the state of the substance rather than causing an increase in temperature. This is called Latent Heat.

Once all the substance has changed state then the temperature begins to rise again.



Def: The Specific Latent of Fusion (l_f) of a substance is the amount of heat energy need to change 1 kg of the substance from a solid to a liquid without a change in temperature.

Def: The Specific Latent of Vaporisation (l_v) of a substance is the amount of heat energy needed to change 1 kg of the substance from a liquid to a gas without a change in temperature.

The unit of Specific Latent Heat is the Joule per kilogram (Jkg^{-1}).

Formula:

Heat needed to change state = Mass × Specific Latent Heat

$$Q = ml$$

Example:

How much heat energy is required to convert 8 kg of ice at 0 °C to water at 0 °C

Example:

How much heat energy is needed to convert 80 grams of water at 30 °C to 80 grams of steam at 100 °C.

Heat Pump

The Heat Pump is a device that extracts available heat from one area and transfers it to another to either heat or cool an interior space.

1. Refrigerator
2. Perspiration

Heat Transfer

1. Conduction

Def: Conduction is the movement of heat energy through a substance by the passing on of molecular vibration from molecule to molecule, without any overall movement of the substance.

These substances are called thermal conductors. If one then of the conductor is hot, the vibration of the molecules will spread the heat throughout.

Know how to demonstrate conduction/convection/radiation from the junior cert experiments.

U-Value

U-Values are used in domestic situations to give an indication of how well a substance (roof, walls, tiles, etc) allows heat to flow (conduct) through it. U-Values are a measure of the *conductivity* of a substance, i.e. a structure that is a good insulator has a low U-Value.

Def: The U-Value of a structure is the amount of heat energy conducted per second through 1 square metre of that structure when a temperature difference of 1° C is maintained between its ends.

2. Conduction

Def: Convection is the transfer of heat through a fluid by means of circulating currents of fluid caused by the heat.

Because hot water expands, it is less dense than cooler water and so rises. This principle is used in domestic hot water and heating systems.

3. Radiation

Def: Radiation is the transfer of heat energy from one place to another in the form of electromagnetic waves.