A2 Level Physics

Chapter 12 – Thermal Physics

12.1.1 Temperature

Notes

Temperature and Thermal Equilibrium

Temperature

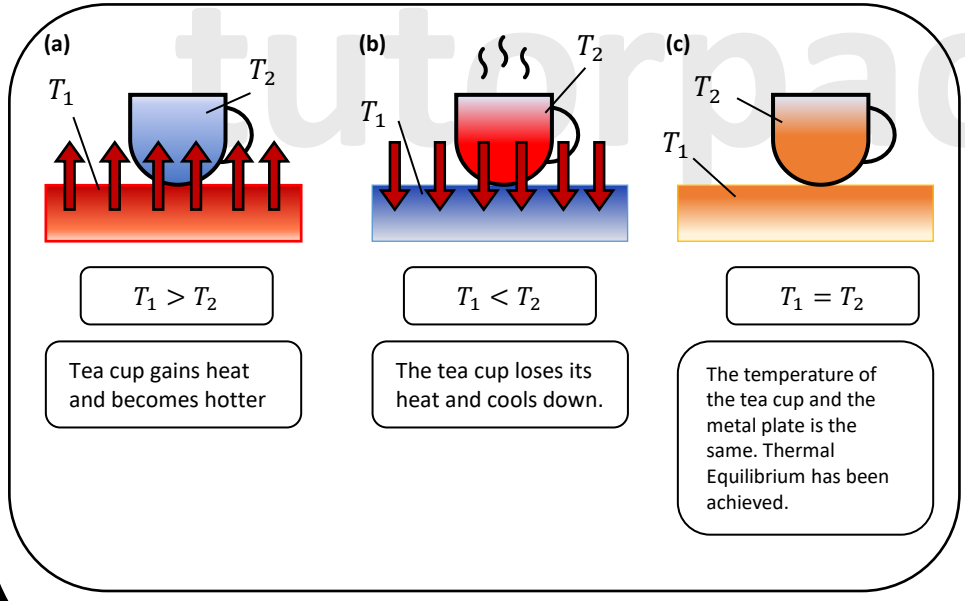
The temperature of an object is a measurement of the object's degree of hotness. In other words, it is used to express how hot or cold something is.

Temperature must not be confused with heat.

Heat is a type of energy that can be transferred from one object to another or even created by converting other types of energy into heat.

Thermal Equilibrium

Heat flow and thermal equilibrium between two objects in contact with each other is shown in the diagram below.



Temperature and Thermal Equilibrium

A cup of tea is placed on a very hot metal plate in diagram (a). Heat goes from the plate to the cup, which heats up, hence the plate's temperature (T_1) must be higher than the cup's temperature (T_2).

The cup containing the tea is placed on a very cold metal plate in diagram (b). The plate's temperature (T_1) is substantially lower than the cup's temperature (T_2), therefore heat transfers from the cup to the plate and the cup gets cooler.

After a while the rate of heat flow from the cup to the plate becomes equal to the rate of heat flow from the plate to the cup. As a result, the temperature of the cup and the temperature of the plate are the same, and the two items are in **Thermal Equilibrium**.

Practical Temperature Scales

A thermometer calibrated on an appropriate temperature scale is used to measure temperature.

Fixed points, which are known degrees of hotness that can be accurately repeated, are used to define a temperature scale. These are the temperatures at which physical qualities, such as melting and boiling, can be seen.

The Celsius Scale

On this scale:

The unit of measurement is the:

$$Degree\ Celcius\ (°C)$$

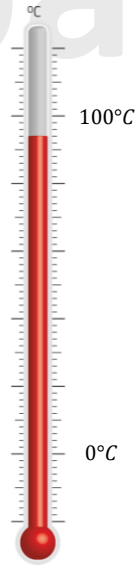
And the symbol used for temperature is:

$$\theta\ (greek\ letter\ 'Theta')$$

The Celsius scale of temperature is defined in terms of:

1) Steam point, 100℃. This is the temperature at which pure liquid water and water vapour are in equilibrium at standard atmospheric pressure ($1 \times 10^5\ Pa$).

2) Ice point, 0℃. This is the temperature at which pure water ice is in equilibrium with liquid water at standard atmospheric pressure ($1 \times 10^5\ Pa$).



tutorpacks.co.uk

Practical Temperature Scales

Temperature scales are divided into a specific number of degrees between the two fixed points.

The gap between the upper and lower fixed points is called the fundamental interval.

Since the upper fixed point of the Celsius scale is 100°C and the lower fixed point is 0°C, the basic interval is 10 degree intervals.

Practical Temperature Scales

The Thermodynamic (Kelvin) Scale

On this scale:

The unit of measurement is:

$$Kelvin\ (K)$$

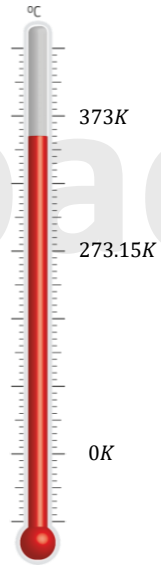
And the symbol used for temperature is:

$$T$$

The thermodynamic (Kelvin) temperature scale, commonly known as the Absolute Scale, is defined in terms of:

1) Triple point of water, $273.15K$. This is the temperature at which ice, water, and water vapour exist in equilibrium.

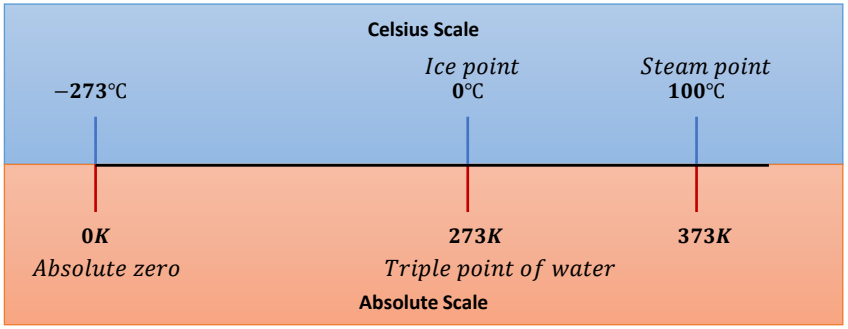
2) Absolute zero, $0K$, which is the coldest temperature achievable. Regardless of the material, an object at absolute zero has minimum internal energy.



Practical Temperature Scales

Comparing the Celsius scale to Kelvin Scale

On the Celsius scale, the ice point is 0°C, while on the absolute scale, it is 273K. The steam point has been raised by 100 degrees Celsius.



Therefore, knowing the above information, the following equations can be used to convert between the Celsius and Kelvin scales:

Temperature in ℃ = Absolute temperature in Kelvin (K) - 273.15

$$\boldsymbol{\theta/℃ = T/K - 273.15}$$

Temperature in Kelvin = Temperature in ℃ + 273.15

$$\boldsymbol{T/K = \theta/℃ + 273.15}$$

Example: Convert $155℃$ to Kelvins:

$$155℃ + 273.15 = 428.15K$$

Therefore $155℃ = 428.15K$

The **Kelvin** is defined as:

A 1K temperature difference is equivalent to a 1°C temperature difference.

About Absolute Zero

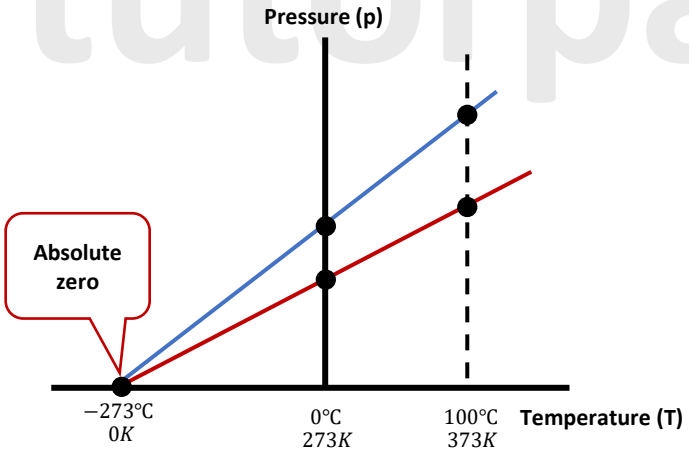
The thermodynamic temperature scale is based on absolute zero, the lowest temperature possible (that in theory can be reached). We say in theory because, while physicists have gotten close to obtaining $0K$ or $-273°C$, they have never achieved it in actuality. Remember, no object can have a temperature below absolute zero.

Experiment to get Absolute Zero

The pressure of a fixed mass of gas in a sealed container of fixed volume decreases as the gas temperature is reduced.

When the pressures measured at the ice point (0°C or 273K) and the steam point (100°C or 373K) are plotted on a graph, the line connecting the two points cuts the temperature axis at -273°C.

This is true regardless of the type of gas or the amount of gas used.



About Absolute Zero

The Kelvin scale is based on the lowest possible temperature, which is a fundamental aspect of nature. The Celsius scale, on the other hand, is based on the qualities of a substance, notably water, which was chosen for convenience rather than any fundamental reason.

tutorpacks.co.uk

For more revision notes, tutorials and worked examples please visit www.tutorpacks.co.uk.

For more revision notes, tutorials and worked examples please visit www.tutorpacks.co.uk.