

Chapter 14 Temperature

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14.1 Thermal equilibrium

Candidates should be able to:

- 1 understand that (thermal) energy is transferred from a region of higher temperature to a region of lower temperature
- 2 understand that regions of equal temperature are in thermal equilibrium

- The candidate must first understand the difference between temperature and thermal energy (heat)
- **Temperature is a numerical measure of the average kinetic energy of individual atoms.**
- The hotter the object the faster its atoms vibrate which in turn means higher temperature.
- The SI unit for temperature is **Kelvin**
- **Thermal energy (heat) is energy.**
- The SI unit is in **Joules**.
- **Thermal energy is transferred from a region of higher temperature to a region of lower temperature**
- The energy transfer will continue until **both regions are at the same temperature.**
- **Thermal equilibrium** is said to be achieved when this happens.



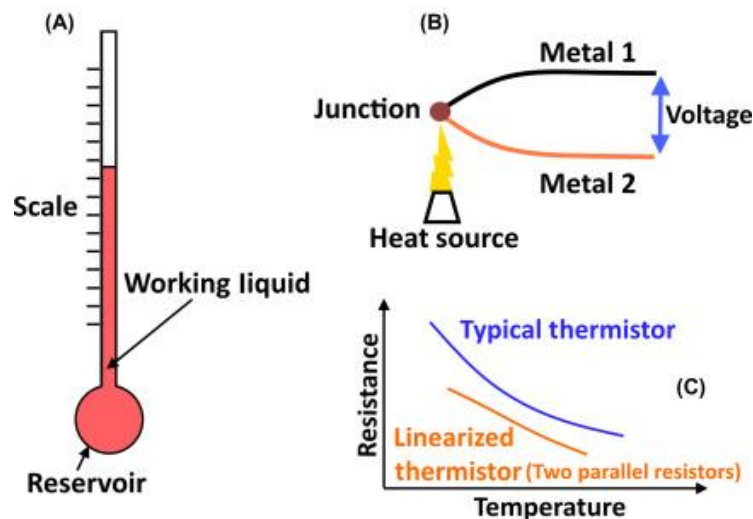
- The mechanism by which thermal energy is transferred is by either **conduction**, **convection** or **radiation**.

14.2 Temperature scales

Candidates should be able to:

- 1 understand that a physical property that varies with temperature may be used for the measurement of temperature and state examples of such properties, including the density of a liquid, volume of a gas at constant pressure, resistance of a metal, e.m.f. of a thermocouple
- 2 understand that the scale of thermodynamic temperature does not depend on the property of any particular substance
- 3 convert temperatures between kelvin and degrees Celsius and recall that $T/K = \theta/^\circ\text{C} + 273.15$
- 4 understand that the lowest possible temperature is zero kelvin on the thermodynamic temperature scale and that this is known as absolute zero

- A thermometer is any device that is used to measure temperature.
- There are many types of thermometer e.g. liquid-in-glass, thermocouple, bimetal thermocouple, etc.
- Each type of thermometer uses a physical property of a material that varies with temperature e.g.



(A) Liquid-in-glass thermometer (B) Thermocouple (C) Thermistor

-**The density of a liquid:** a liquid-in-glass thermometer depends on the density change of a liquid (either alcohol or mercury). The thin glass capillary tube contains the liquid that expands or contracts depending on temperature.

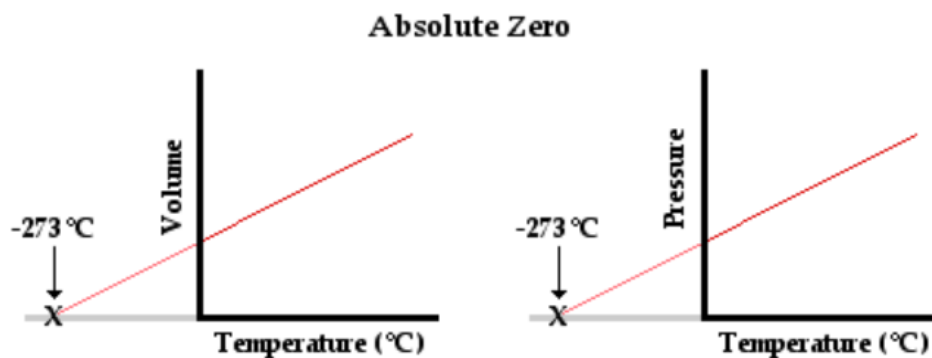
-**The volume of a gas at constant pressure:** the volume of gas is directly proportional to its temperature when at constant pressure (Charles' Law)

$$v \propto T$$

-Resistance of a metal: Electrical resistance changes with temperature (Chapter 10 DC Circuits). Recall that for metals, resistance increases with temperature. For thermistor resistance decreases with temperature.

-E.m.f. of a thermal couple: A thermocouple is an electrical device used as a temperature sensor. It consists of two wires of different metals attached to each other to create a junction at one end. When this junction is heated, an e.m.f. is produced between the wires and measured by a voltmeter.

- You will need to be able to give an example for each of the above types and explain how it works
- The **Kelvin scale** is also called the **thermo dynamic scale**.
- Absolute zero is defined as **the temperature at which atoms and molecules in all substances have zero kinetic and potential energy**.
- At absolute zero, molecules is assumed to have no spacing between them as well.



A volume vs. temperature and a pressure vs. temperature plot will each have an x-intercept of -273 C. The volume and the pressure of a gas seem to reduce to 0 at a very specific temperature (assuming the gas remains as a gas).

- On the thermodynamic scale, absolute zero is defined as:
The lowest temperature possible. Equal to 0 K or -273.15 °C
- The difference between Kelvin and °C is that Kelvin will never have a negative number and that the lowest it can go is 0 K.
- To convert °C to Kelvin use:

$$\text{Temperature in Kelvin} = \text{Temperature Celsius} + 273.15$$

14.3 Specific heat capacity and specific latent heat

Candidates should be able to:

- 1 define and use specific heat capacity
- 2 define and use specific latent heat and distinguish between specific latent heat of fusion and specific latent heat of vaporisation

- Recall the definition of specific heat capacity from IGCSE / SPM.
- **Specific heat capacity (c) is the heat required to change the temperature by 1°C or 1K for a mass of 1kg of the substance.**

$$\text{Specific Heat Capacity, } c = \frac{\text{The amount of thermal energy}}{\text{Change in temperature per unit mass}} = \frac{Q}{\theta m}$$

- The SI unit for specific heat capacity is $\text{J kg}^{-1}\text{K}^{-1}$ or $\text{J kg}^{-1} \text{ } ^\circ\text{C}^{-1}$
- The specific heat capacity tells us how much a substance can "absorb" thermal energy before its temperature increases.
- E.g., a metallic substance like copper has less heat capacity than wood. If both substances are exposed to heat simultaneously, the copper will have a higher temperature than the wood.
- Typically, a substance with a **high c**, will heat up or cool down **slower**.
- A **low c** substance will heat up and cool down **faster**.
- **Specific latent heat is defined as the amount of heat required to change 1kg of substance at a constant temperature.**

$$\text{Specific Latent Heat, } l = \frac{\text{The amount of thermal energy}}{\text{per unit mass}} = \frac{Q}{m}$$

- The SI unit for specific latent heat is J kg^{-1} .
- There are two types of specific latent heat.
- **Specific latent heat of fusion is the amount of heat required to change 1kg of substance from solid to liquid without changing the temperature.**
- **Specific latent heat of vaporization is the amount of heat required to change 1kg of substance from liquid to gas without changing the temperature.**