Chapter 14 Temperature

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:

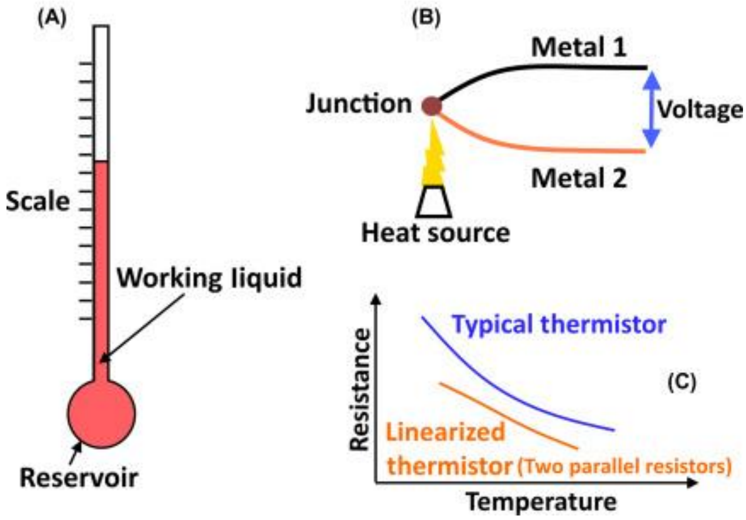
1 understand that a physical property that varies with temperature may be used for the measurement of temperature and state examples of such properties, including the density of a liquid, volume of a gas at constant pressure, resistance of a metal, e.m.f. of a thermocouple

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 = θ / °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) Thermisotor

-**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.

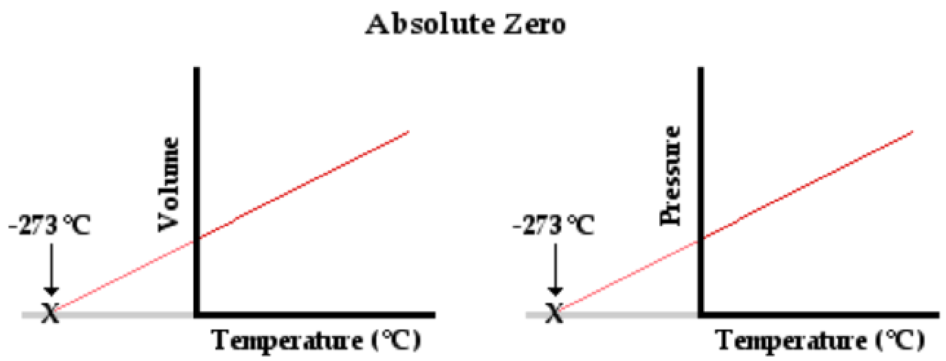
-**The volume of a gas at constant pressure:** the volume of gas is directly proportional to its temperature when at constant pressure (Charles' Law)

$$v \, \alpha \, T$$

-**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:

Temperature in Kelvin = 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 amount of heat required to change the temperature by 1°C or 1K for a mass of 1kg of the substance.**

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

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

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

- 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**.