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Thermal Physics

NATIONAL JUNIOR COLLEGE

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Section 1 - Temperature and thermal equilibrium

Temperature is the degree of hotness or coldness. Two bodies in thermal contact are said to be in thermal equilibrium with each other if they are at the same temperature. If two bodies are in thermal equilibrium with a third body, then they must be in thermal equilibrium with each other (*Zeroth Law of Thermodynamics*).

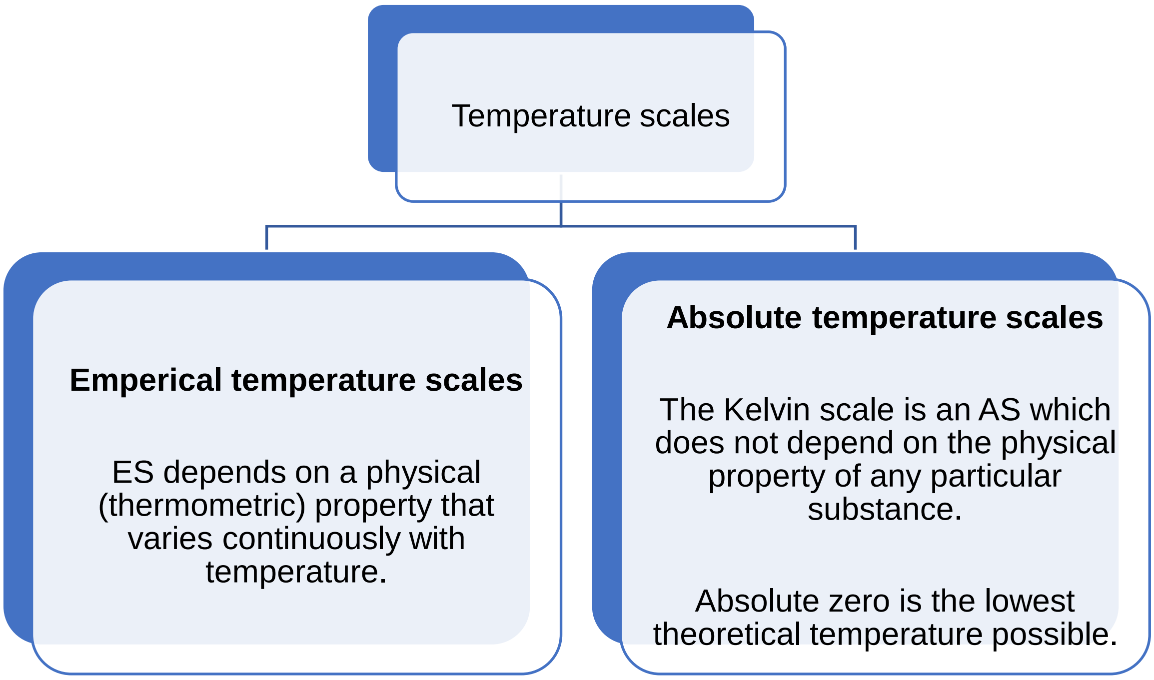

Figure 1.1: Two types of temperature scales

Section 2 - Kinetic Theory, internal energy and heat

Kinetic Theory supposes that all matter is composed of a large number of small particles which are in random motion.

Solids	Liquids	Gases
Strong intermolecular forces.	Fairly weak intermolecular forces.	Weak intermolecular forces.
Small separation between atoms/molecules.	Slightly greater separation between atoms/molecules.	Wide separation between atoms/molecules.
Atoms/molecules vibrate about fixed centres, arranged in a crystal lattice.	Atoms/molecules have greater freedom of movement, shows regularity of structure only over short distances.	Atoms/molecules move freely between collisions.

Since the atoms/molecules in matter vibrate, they possess kinetic energy ($\mathrm{E_k}$). At the same time these particles also experience intermolecular forces, hence they also possess potential energy ($\mathrm{E_p}$). The internal energy (U) of a system is the sum of the random distribution of kinetic and potential energies associated with the molecules of the system and can be determined by the state of the system.

$$\mathrm{U} = \mathrm{E_p} + \mathrm{E_k}$$

Heat refers to the transfer of energy. When a system absorbs heat, the internal energy increases.

Section 3 - Heat capacity and latent heat

The heat capacity (C) of a substance is the amount of thermal energy required to raise the temperature of the whole substance by one Kelvin. The unit of heat capacity is $\mathrm{JK^{-1}}$.

$$\boxed{\mathrm{C} = \frac{\mathrm{Q}}{\Delta \mathrm{T}}}$$

The specific heat capacity (c) of a substance is the amount of thermal energy required to raise the temperature of a unit mass of that substance by one Kelvin. The unit of specific heat capacity is $\mathrm{Jkg^{-1}K^{-1}}$.

$$\boxed{\mathrm{c} = \frac{\mathrm{Q}}{\mathrm{m}\Delta \mathrm{T}}}$$

When a substance undergoes a phase change, thermal energy has to be supplied to or removed from the substance. The amount of thermal energy required is called the latent heat. The unit of specific latent heat is $\mathrm{Jkg^{-1}}$.

Section 4 - The Ideal Gas Equation

The equation of state for an ideal gas is:

$$\boxed{pV = nRT}$$

where n is the number of molecules of gases and R is the molar gas constant.

The internal energy of n moles of an ideal gas is:

$$\boxed{U = \frac{3}{2}NkT = \frac{3}{2}nRT = \frac{3}{2}pV}$$

Section 5 - 1st Law of Thermodynamics

The First Law of Thermodynamics suggests that, the increase in the internal energy of a system is the sum of the work done on the system and the heat supplied to the system.

$$\Delta U = q + w$$

The total work done on the gas is given by the area of the area under the p-V curve. If the gas is compressed, work is done on the gas, vice versa.

The following equations could be used to find the change in internal energy:

$\Delta U = \frac{3}{2}nR(T_f - T_i)$	$\Delta U = \frac{3}{2}(p_f V_f - p_i V_i)$

Section 6 - Thermodynamic Processes

Isothermal	Constant temperature
Isobaric	Constant pressure
Isochoric	Constant volume
Adiabatic	No heat exchange
Cyclic	Initial and final states are the same