University of Mosul

College of Science

Department of Physics

Second Stage

Heat and Thermodynamic

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Lecture 2: Definition & Temperature scales

Preparation

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Chapter two

Energy : the ability to accomplish work and includes stored energy and Transit Energy. Stored energy is in several forms: chemical energy, electrical energy, internal energy, and mechanical energy (potential and kinetic). As for the transient energy, it is in two forms: heat and work

Heat and Work: They are the only two forms of energy that cannot exist in the form of stored energy, but only exist while crossing the boundaries of the system (energy exchange between the entity and its surroundings)

When work or heat crosses the boundaries of the entity and enter it, their existence ends as work or heat, and they turn into stored energy, such as internal energy and others. This can be likened (i.e. work and heat) to rain water. When rain falls on the sea, it turns into additional water in the sea, and it is not called rain. The stored energy while rain is like heat and work.

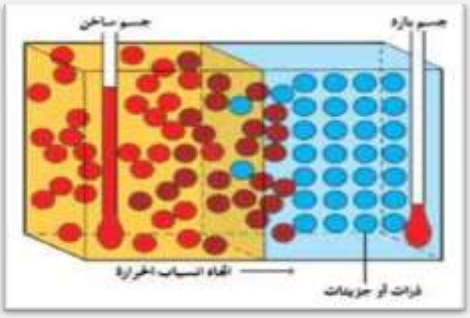
To remove the ambiguity in the concept of temperature and work, it can be summarized in the following points:

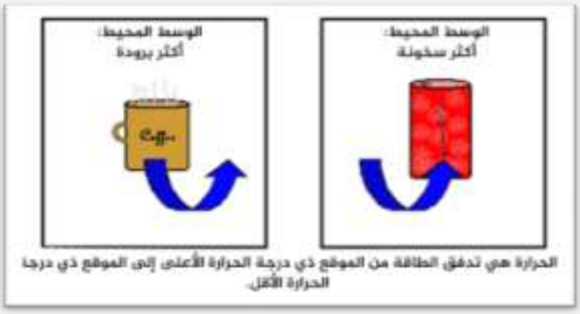
- The heat or work represents the energy crossing the boundaries of the entity, that is, it is a boundary phenomenon observed only at the boundaries of the entity

- Heat and work are a temporary phenomenon, that is, they are associated with the transfer or transit of heat Giving heat to the entity is done in more than one way, for example by direct heating, mechanical friction, passage of electric current, chemical reaction, and others.

Concept of heat

Heat is defined as: energy in transit or transport. It is a form of energy that moves across the boundaries of the system due to the difference between the temperature of the system and its surroundings. When two objects touch one hot and the other cold, there is a form of energy that moves from the hot body to the cold body, and this transferred form is called heat or thermal energy. The flow of heat from the hot system to the cold environment continues until equilibrium is achieved, where the temperature of the system is equal to the temperature of the environment.





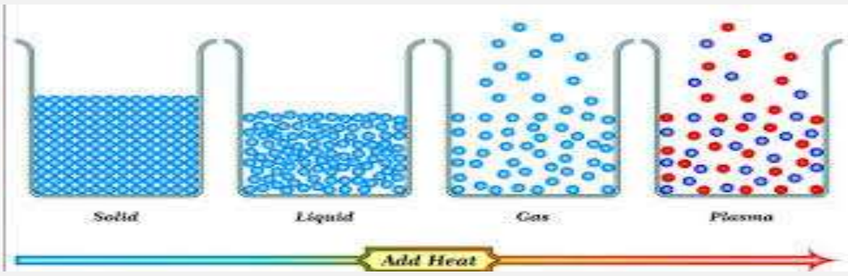
Internal Energy

It is the sum of the energies possessed by all the particles involved in the formation of the system and it is denoted by the symbol U and these energies are:

1. A translational kinetic energy related to the velocity of the particles and is mainly responsible for determining the temperature of the system.Rotational energy that depends on the rotation of atoms in molecules in one or more directions.
2. The vibration kinetic energy that depends on the vibration of the atoms involved in the composition of the molecules.
3. The potential energy of the atoms and molecules of the system resulting from the position of these particles in relation to each other.
4. Nuclear and electronic energies within the structure of atoms and molecules.

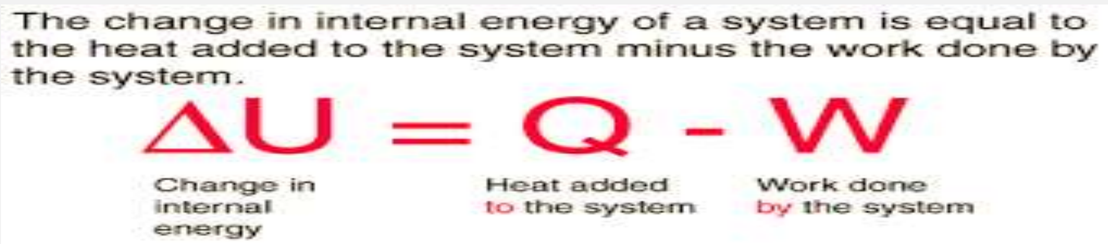
If a system is given a quantity of thermal energy, that energy will spread and be distributed among the atoms and molecules of the system and increase its energies in proportion to the amount of heat entering the system, meaning that the incoming heat is transformed into an increase in the internal energy of the system, which may appear in one of the following purposes:

1. Increase the system temperature.
2. Changing the state of the system from solid to liquid or from liquid to vapor (latent heat
3. Increase the separation between the molecules of the system that accompanies the expansion, and this expansion takes place against the forces of mutual attraction between the molecules. As shown in the figure below



The increase in internal energy is denoted by U

The same thing happens if the environment performs work on the system (W -), then it increases the internal energy, and in the case of drawing a quantity of heat (-Q or –dQ) from the system through contact with a cooler object, the internal energy will decrease and if the system performs work On the perimeter (W +) this is done at the expense of its internal energy and will therefore decrease.



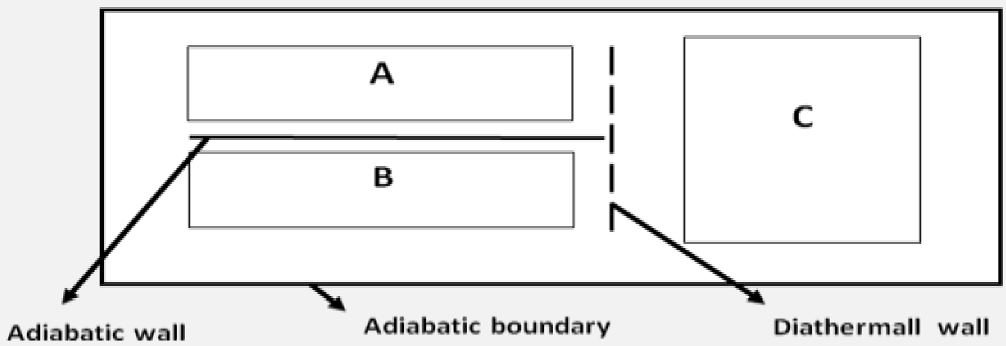
Temperature

The temperature of a body is a measures relative hotness or coldness, Heat is a form of energy that is transferred from one body to another due to the difference between the temperature of the two bodies, and when there is no heat exchange between them upon contact, they are said to be in a state of thermal equilibrium. Therefore, temperature can also be defined as: that characteristic that determines whether a system is thermally balanced with another system or more adjacent to it.

The zeroth law: when any two bodies are reach separately (singly) in thermal equilibrium with a third body, they are also in thermal equilibrium with each other. This law specifies the condition of equal temperature, but does not specify the amount of temperature numerically

In order to measure the temperature and determine its amount digitally, a measuring device called a thermometer must be built

If we imagine that there are two systems A and B, which are thermally separated from each other by an adiabatic wall (i.e. the passage of heat between the two systems is not allowed), let us assume that we have a third system C in thermal contact with A, B by means of a diathermy wall, i.e. (allowing the passage of heat between neighboring systems) in One. This group is thermally isolated from the external environment by placing it inside an adiabatic envelope, and after a sufficient period of time has elapsed, A and B will separately reach a state of thermal equilibrium with C, and then the properties of each of them will cease to change and therefore the temperature of each of A and B will be equal .



For the purpose of measuring the temperature and determining its amount digitally, a special device called a thermometer must be built, and to build the thermometer, the following requirements must be met:

1**. Structure**

2. Staging Temperature Scales

3. Sensitivity

Thermometer of Installation:

The thermometer composition depends mainly on the thermogenic substance (a solid, liquid or gas substance) that has physical properties that change with temperature and the property that changes with temperature and can be measured is called the thermal property, an example of thermodynamic properties is the change in body dimensions, the extension Phenomena phenomenon and the change in Gas pressure when the volume is fixed.

Important note: When building a thermometer, the appropriate and necessary selection of the thermal material is based on the regular change in the value of the thermocouple property with the increase in the temperature.

Temperature Scales :

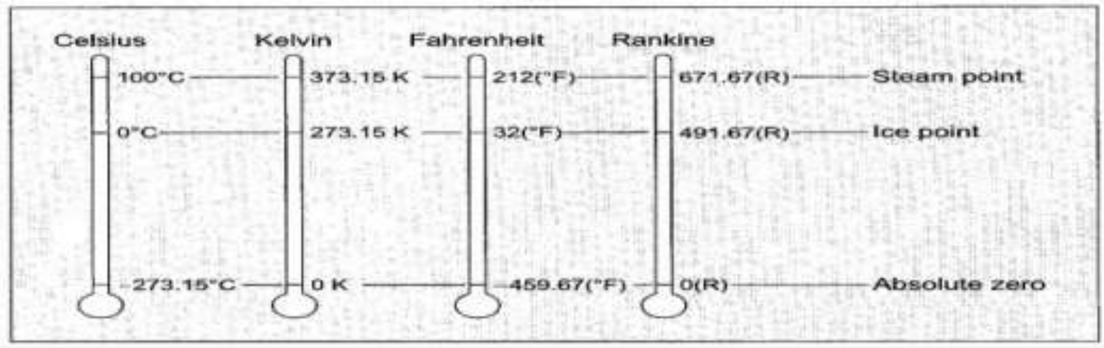
For this purpose, some standard fixed points are chosen as reference points on which the thermometer scale is based, and the grading is by dividing the property value between the fixed points into equal parts.

Centigrade scale: The property value is divided between the melting point of ice (0C˚) and the boiling point of water (100 C˚) (under normal pressure) into 100 equal parts, and each part represents one degree Celsius.

Fahrenheit scale: The same distance is divided into one hundred and eighty equal parts, and each part represents one degree Fahrenheit. This grading starts from 32 degrees (the freezing point) and the boiling point of water, which is 212 degrees.

The Kelvin scale: 273.15, the freezing point and the boiling point of water, which is 373.15.

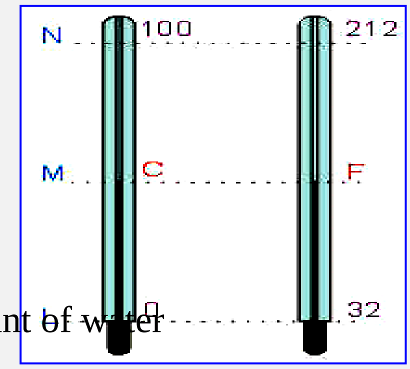
• **Rankine scales:** 492, the freezing point, and the boiling point of water, which is 672



The relationship between the temperature values of the three scales is:

$$\mathbf{C = K - 273.15 = \frac{5}{9}.(F - 32)}$$

To find the relationship between the Celsius and Fahrenheit thermometers, two Celsius and Fahrenheit thermometers are taken and placed in a water bath of a certain temperature. We note that the mercury will expand in both thermometers and reach a point (M as in the figure below).



N: Boiling point of water

M: C$^{\circ}$,F

L : Freezing point of water

∴ ML = C-0 =F-32………..(1)

When the tow thermometer are placed in boiling water, the mercury reaches N.

NL=100-0 =212-32……...(2)

$$\frac{ML}{NL} = \frac{C-0}{100-0} = \frac{F-32}{212-32} \ldots \ldots \ldots (3)$$

$$\frac{ML}{NL} = \frac{C}{100} = \frac{F-32}{212-32} = \frac{100}{180}.(\mathrm{F}-32)$$

$$C = \frac{100}{180} - (\mathrm{F}-32)$$

$$\mathbf{C} = \frac{\mathbf{5}}{\mathbf{9}}.(\mathbf{F}-\mathbf{32}) \ldots \ldots \ldots \ldots \ldots \ldots (\mathbf{4})$$

Sensitivity of Thermometer

In order for the thermometer to be sensitive and accurate, the following conditions must be met

1. The thermometer will be sensitive and discover any small changes in temperature

2. The conduct of material is very high that the thermometer will be thermal equilibrium in a short time

The thermal capacity of the thermometer material and the thermometer bulb is very small this mean the thermometer not absorb a much heat from the body whose temperature must be determined

Types of Thermometers

Liquid thermometers: These are thermometers that depend on the change in the volume of the liquid with the change of temperature. Example: mercury and alcohol thermometers.

(Mercury thermometer)

The mercury thermometer is installed from a thin-walled glass reservoir filled with mercury and connected to a fine, regular-section capillary tube closed at its upper end. When the thermometer temperature rises, the mercury expands in the reservoir and the mercury level rises in the capillary tube.

The temperature is known to the level of mercury in the cylinder. The idea of scale is extended to the expansion of mercury at high temperature and the contraction of its volume at temperature. As for the remaining part in the cylinder, it is filled with nitrogen or air is drawn from it

1. Its thermal capacity is low

2. Good conductor of heat

3. Dark liquid

4. Do not wet the walls of the glass tubes

5. It has a uniform coefficient of expansion over a wide temperature range.

6. Remains in liquid state over a wide range of temperatures, ranging from freezing point (-39°C) to (357°C) boiling point

7. Large volumetric coefficient of expansion (0.0018 per degree).

** **The thermal capacity:** It is defined as the amount of heat energy required to raise the temperature of a given object or a certain amount of a substance with a mass of m 1 C°. Unit heat capacity J / C °*