HEAT ENERGY 1

TEMPERATURE AND ITS MEASUREMENT

In our previous study notes, we defined temperature as the degree of hotness or coldness of a body. When we want to look at it more in-depth, we can say it is the property of an object which determines which way heat energy will flow when it is placed in contact with another object. Heat always flows from a body at a higher temperature to another at a lower temperature. We also distinguished between heat and temperature. We noted that heat is a form of energy known as thermal energy. When a body absorbs heat without changing its state, its temperature rises.

Heat depends on the mass of a body and its temperature. A fixed quantity of heat given to a small body makes it hotter than it would a large body of the same material.

What is heat?

Heat is a measure of the total internal energy of a body. It is a form of energy due to a temperature difference. Temperature is the degree of hotness or coldness of the body and is related to the energy of movement. It is a measure of the average kinetic energy of the molecule in a body. Heat is measured in joule, while temperature is measured in degree Celsius or kelvin.

In the present chapter, we will discuss the various methods of measuring temperature, the relationship between pressure and temperature of a gas, and types of thermometers. We shall also give a molecular explanation of temperature.

By the time we are done with this class, we expect that any student who paid kin attention should be able to;

1. Construct a device for measuring the temperature of a body.
2. Use the variation of;
    a. Pressure of a gas with temperature.
    b. The expansion of solid, liquid or gas with temperature. and
    c. Electrical resistance of a material, to measure the temperature of a body.
3. Distinguish between heat and temperature and between temperature points and temperature intervals.
4. Select those liquids which are suitable for use in liquid-in-glass thermometers form a given list of liquids and their properties.
5. Describe the absolute scale of temperature and explain the meaning of the absolute zero of temperature.
6. Convert a given temperature in the Celsius scale to a temperature on the Kelvin scale.
7. Describe the kinetic molecular model of temperature.

From the course expectation, and the topic, you understand that we hope to explain substantially the concept of temperature measurement. We do this is by first explaining the concept of thermometers which we have already shown to be the measuring instrument for temperature. And to explain the terms associated with thermometers and finally to look at some calculations when working with thermometers.

METHODS OF MEASURING TEMPERATURE.

Our sense of touch can give us a general impression of the degree of hotness or coldness of a body. This is however not a reliable method of estimating or measuring a temperature, because the response of the human sense of touch to a temperature change tends to be influenced by its previous experience. Thus, warm water will feel cool if a hand initially dipped in hot water is transferred to it. Hence in order to gauge accurately the exact degree of hotness, an instrument called the thermometer is used. Thermometers are much more reliable instruments for measuring temperatures.

Table 10.1			
Type of thermometer		Thermometric substance	Physical property
1	Liquid in glass thermometer	Mercury or Alcohol	Change in volume of liquid with temperature
2	Gas thermometer	Gas	Change of gas pressure at constant volume with temperature
3	Resistance thermometer	Resistive wire	Change in the electrical resistance of wire with temperature
4	Thermocouple	Two dissimilar metals (e.g. copper and constantan)	Change in electric potential difference (or current) between two metal junctions at different temperatures
5	Bimetallic thermometer	Two dissimilar metals (e.g. iron and copper)	The differential expansion of the two metals of the bimetallic strip

Thermometers use any physical property of a substance which varies in a known way with temperature, and is easily measurable, as a means of gauging temperature. The substance of whose physical property is so used is known as a thermometric substance.

Fixed temperature and temperature scales of thermometer.

Each thermometer has two reference temperature or fixed points called the upper and the lower fixed temperature points. When we talk about fixed temperature and temperature scales, we actually refer to the range within which a certain thermometer is designed to measure temperature. That is where we have the upper and lower fixed points,. We can call this the maximum and minimum fixed points.

The upper fixed point is the temperature of steam from pure water boiling at standard atmospheric pressure of 760 mm of mercury.

The lower fixed point is the temperature of pure melting ice at standard atmospheric pressure of 760 mm of mercury.

The difference in temperature between the two temperature points is called the fundamental interval (or temperature interval) of a thermometer. The calibration of this interval depends on the temperature scale chosen. There are three types of scales in current use.

1. The Celsius scale,
2. The Fahrenheit scale and
3. The absolute (or thermodynamic or kelvin) scale.

The lower and upper fixed points are 0^0 C and 100^0 C for the Celsius scale; 32^0 F and 212^0 F for the Fahrenheit scale. The fundamental interval in the Celsius scales is divided into 100 equal units, each unit representing 1^0 C in this scale. For the Fahrenheit scale, the fundamental interval is divided into 180 units or degrees Fahrenheit.

The S I unit of temperature is the kelvin (K) and its scale is called the absolute or thermodynamic temperature scale. The fundamental interval for the Kelvin scale goes from a lower fixed points of 273 K to an upper fixed point of 373 K. i.e. a difference of 100 K. this is divided into 100 equal parts each of which is equal to 1 K. temperatures on this scale are not measured in degrees but in units called kelvin (k). Hence the unit symbol K is written without the degree sign. The lower fixed point or the zero on the Kelvin scale is equal to $-273\ ^0$C. It is called the absolute zero.

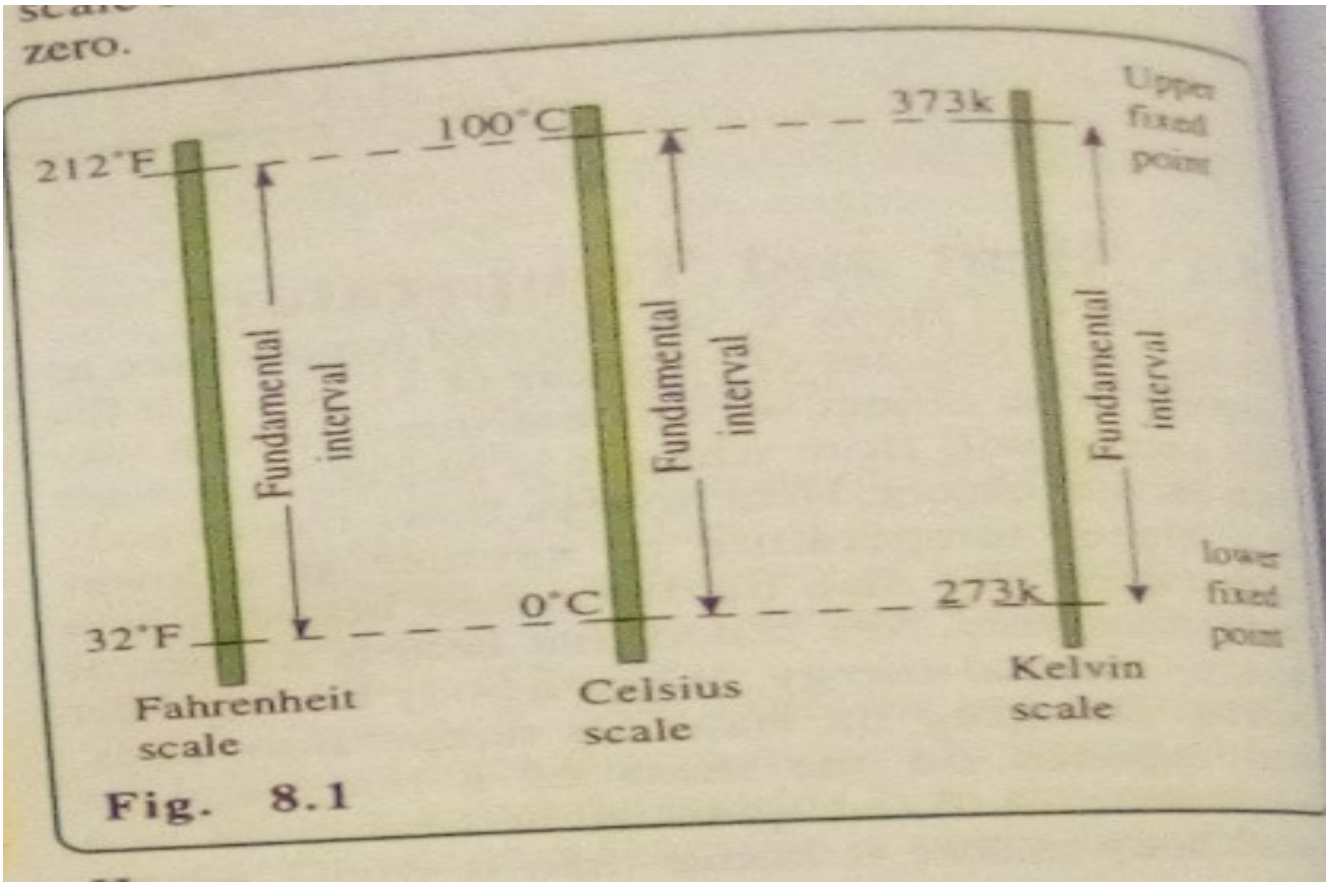

Fig. 8.1

Hence $0^0C = 273\ k,$ $\quad -273^0C = 0\,\mathrm{k}$

A temperature of $\theta^0 C$ in the Celsius scale is related to T of the Kelvin scale by $T = \theta + 273$

The upper fixed point on the Kelvin scale is 373 k or 100°c. Nevertheless a temperature change of 1°c is equal to a temperature change of 1 k. thus we can for example say that the thermal expansivity of brass is $18 \times 10^{-6}/k$ *or* $18 \times 10^{-6}/^0 c$ or that a heat quantity which has a value of 100 joules per °C has a value of 100 J/K in S I units.

Example

The lower and upper fixed points of a certain thermometer are 30 cm apart. At a certain day, the length of mercury thread in the thermometer is 9 cm above the ice point (0^0 C). What is the temperature recorded by the thermometer in?

a. Celsius scale
b. Kelvin scale

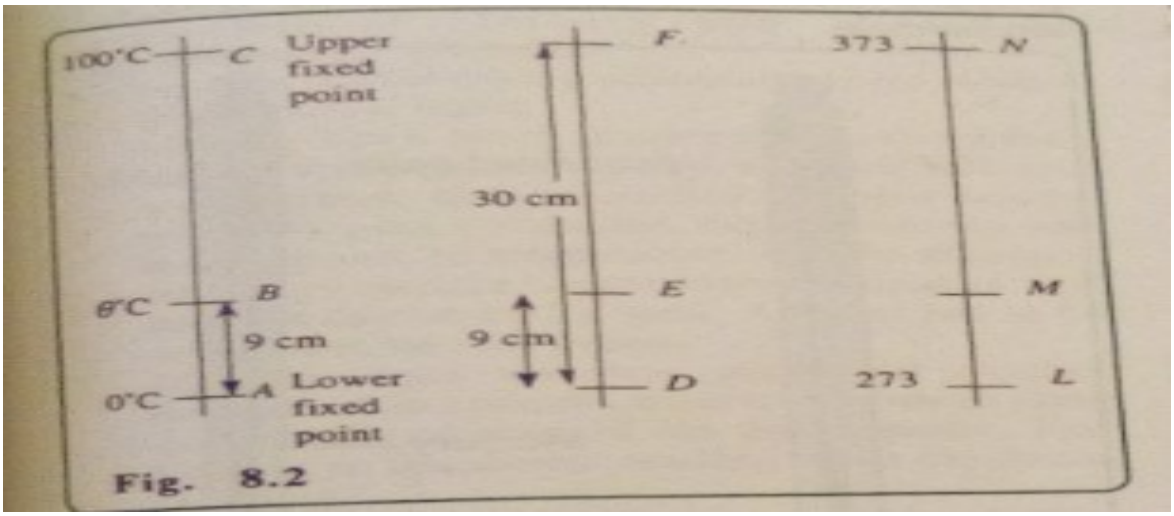

Fig. 8.2

Solution

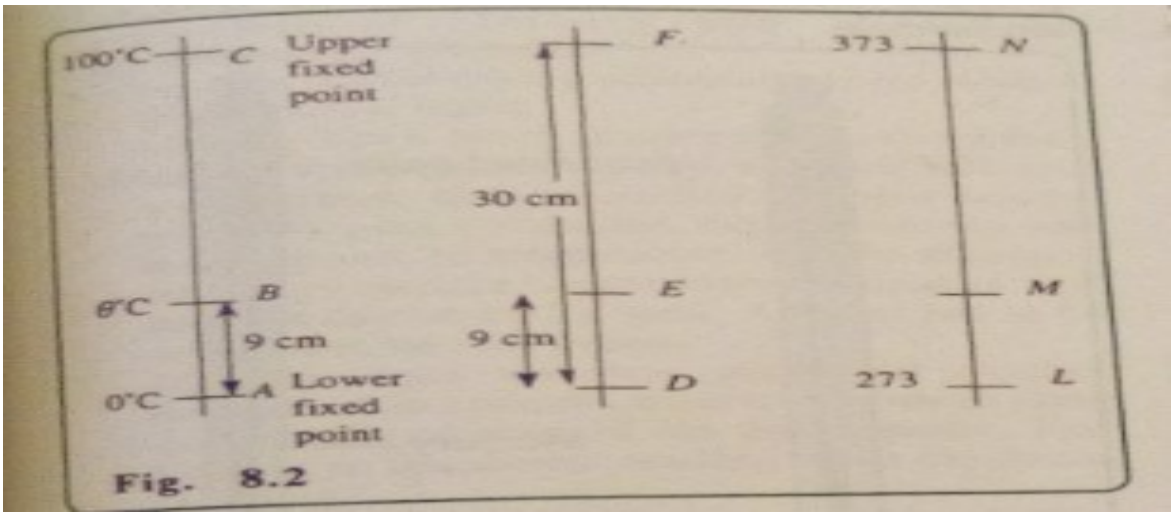

Fig. 8.2

Let the temperature recorded in Celsius be $\theta^0 C$. The fixed points are 30 cm apart. We assume the temperature increases in a linear scale. From the figure shown above, by taking proportions.

$\frac{AB}{AC} = \frac{DE}{DF} = \frac{LM}{LN}$ $\frac{\theta - 0}{100 - 0} = \frac{9}{30}$ $\frac{\theta}{100} = \frac{9}{30}$	$\theta = \frac{9}{30} \times 100 = 30^0 c$ $from\ T = \theta + 273$ $= 30 + 273 = 303k$

The upper fixed points

Here we want to discuss a possible way to calculate the upper fixed point of an unmarked thermometer using a simple apparatus called a hypsometer.