TOPIC 10 Temperature

Objectives

Candidates should be able to:

(a) explain how a physical property which varies with temperature, such as volume of liquid column, resistance of metal wire and electromotive force (e.m.f.) produced by junctions formed with wires of two different metals, may be used to define temperature scales

(b) describe the process of calibration of a liquid-in-glass thermometer, including the need for fixed points such as the ice point and steam point

NOTES

10.1 Temperature

1. A measure of the degree of 'hotness' or 'coldness' of a body.
2. SI Unit: Kelvin (K)
3. Commonly-used unit is degree Celsius (^{o}C): θ (K) = θ (^{o}C) + 273.15

10.2 Measurement of Temperature

1. Material for temperature measurement: Substance/ material which possesses temperature-dependent property and thus can change continuously with temperature variations.

2. Temperature-dependent (Thermometric) Properties:

Thermometric Property	Thermometer	Range
Volume of a fixed mass of liquid (**e.g.** mercury or alcohol)	Mercury Alcohol Clinical thermometer	–10 ºC to 110 ºC –60 ºC to 60 ºC 35 ºC to 42 ºC
Electromotive force (e.m.f.) (between hot and cold junctions of two different metals joined together)	Thermocouple	–200 ºC to 60 ºC Common ones
Resistance of metal **e.g.** Platinum	Resistance thermometer	–200 ºC to 1200 º C
Pressure of a fixed mass of gas at constant volume	Constant-volume gas thermometer	Estimated –258 ºC to 1027 ºC

10.3 Temperature Scale

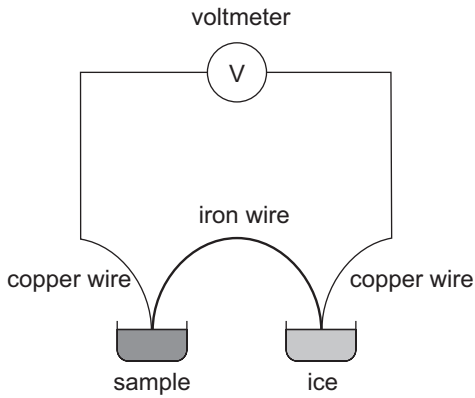
1. Temperature is measured with reference to 2 fixed points:
   (a) Lower Fixed Point or Ice point (0 °C):
   Temperature of pure melting ice at standard atmospheric pressure.
   (b) Upper Fixed Point or Steam point (100 °C):
   Temperature of pure boiling water at standard atmospheric pressure.
2. The length between the 2 fixed points is divided into 100 equal intervals of 1 °C.
3. Apply the following general formula to calculate temperature of a material:

$$\theta\,°\text{C} = \frac{X_\theta - X_0}{X_{100} - X_0} \times 100\ °\text{C}$$

where:
θ is temperature of material
X_θ is thermometric property at θ
X_{100} is thermometric property at steam point
X_0 is thermometric property at ice point
i.e. for clinical thermometer, X is the length of the mercury thread at temperature θ; for thermocouples, it is the voltmeter reading at temperature θ.

10.4 The Thermocouple

1. To measure the temperature of an unknown substance:
   (a) One junction is kept at a constant temperature (i.e. ice point).
   (b) The other junction is kept at the point where the temperature is to be measured.



2. Advantages:
   (a) Can withstand high temperature with suitable metals.
   (b) Large temperature range. Can measure very low or very high temperatures.
   (c) Junctions used are sharp and pointed and therefore can be used to measure temperature accurately at a point.
   (d) Rapid response to temperature change.