HEAT

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Heat

- The energy transferred from one body to another without any mechanical work involved is called heat.

When a hot body is kept in contact with a cold body, the cold body warms up and the hot body cools down. Energy is transferred from the hot body to the cold body when they are placed in contact.

- If no transfer of heat takes place between two bodies in contact, then they are said to be in thermal equilibrium
- The internal energy of a body is the sum of kinetic energy and potential

energy of constituent atoms or molecules.

A cold body absorbs energy to become hot.

A hot body has more internal energy than the identical cold body.

Heat is an invisible energy that causes the sensation of hotness or coldness

- In the CGS system, the unit of heat is calorie. The SI unit of heat is Joule. One calorie is equal to 4.2 J.

Temperature

- The temperature of a substance is the degree of hotness or coldness on some chosen scale.

- The effects of heat energy are:

a) Heat energy brings about change in temperature

b) Heat energy brings about change in dimension.

c) Heat energy brings about change in the state.

Temperature scales

- A temperature scale is a way to indicate or measure temperature relative to a starting point and a unit of measurement.
- The temperature scale chosen must be precise, consistent, and accurate. All temperature scales make use of some physical property that changes with temperature.
- The major temperature scales used are the

  Celsius, Fahrenheit, and Kelvin scales.
- Most temperature scales have two fixed points: lower fixed point and upper fixed point.

a) Celsius Scale

- Celsius or centigrade scale is a temperature scale based on the freezing point of water and the boiling point of water.
- The temperature corresponding to the freezing point of water is taken as the lower fixed point and it is taken as 0 ^{0}C.
- The boiling point of water is taken as upper fixed pint and is given a value of 100 ^{0}C.
- The interval between these two temperatures is divided into 100 equal parts and one division is called one degree Celsius (1^{0}C).

b)Fahrenheit scale

- In the Fahrenheit scale, the freezing point of water is taken as 32 ^{0}F, and the boiling point

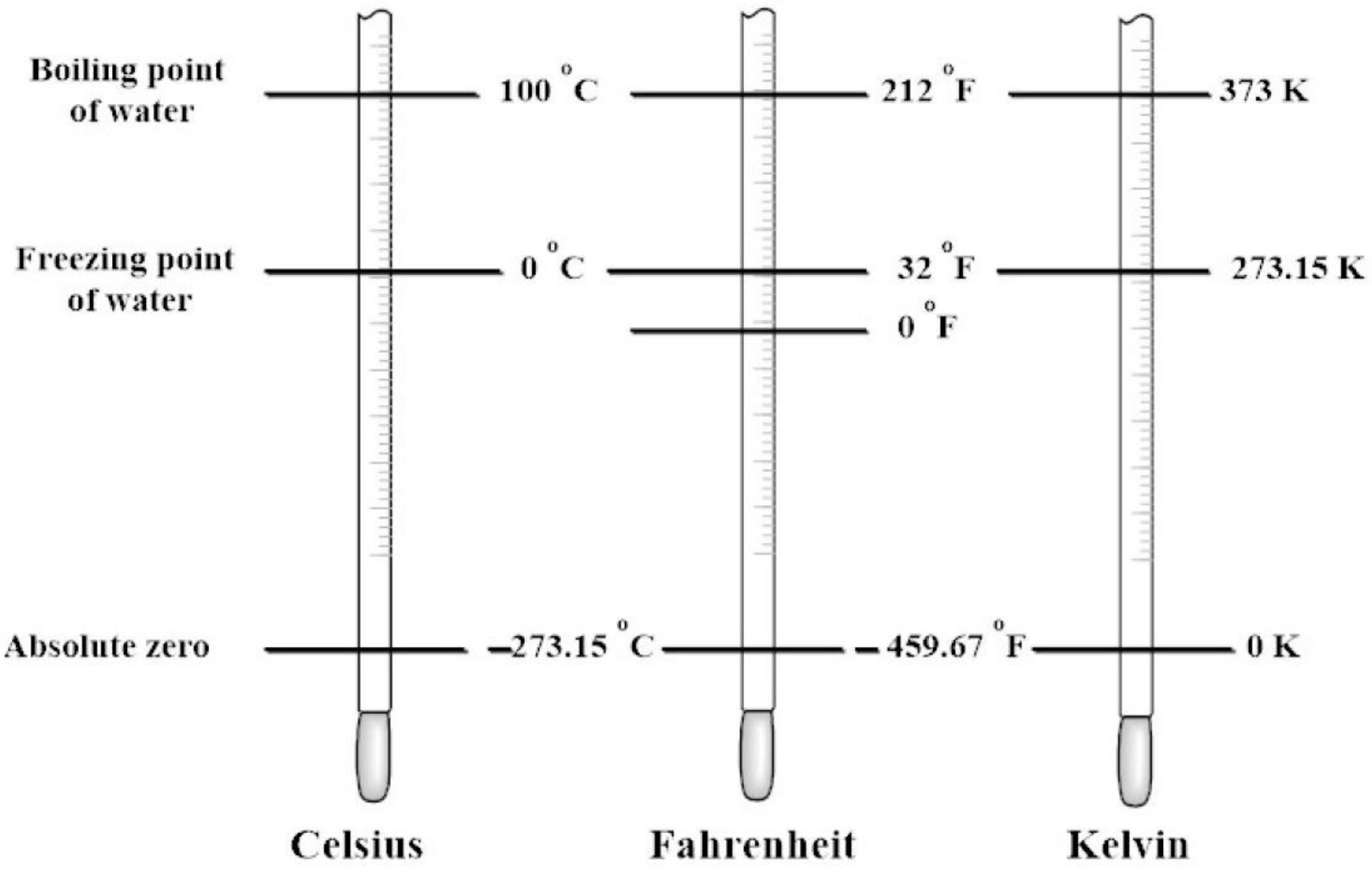
of water is 212 ^{0}F.

The interval is divided into 180 equal parts. Each division is called one degree Fahrenheit (1^{0}F).

c) Kelvin scale

- Kelvin scale is a temperature scale based on absolute zero of temperature.
- Absolute zero, or 0K, is the lowest possible temperature for any substance and it corresponds to a temperature of −273.15° on the Celsius scale.
- In the Kelvin scale, the freezing point of water is taken as 273K and the boiling point of water is 373 K.
- Magnitude of a degree in the Kelvin scale and Celsius scale are equal. Kelvin is the SI unit of temperature.

Comparison of Celsius scale, Fahrenheit scale and Kelvin scale



Conversion between temperature scales

- The relation connecting Celsius, Fahrenheit, and Kelvin scales is given by the following formula where C stands for temperature in Celsius, F stands for temperature in Fahrenheit and K stands for temperature in Kelvin scale.

$$\frac{C-0}{100} = \frac{F-32}{180} = \frac{K-273}{100}$$

$$\frac{C}{5} = \frac{F-32}{9} = \frac{K-273}{5}$$

The equation to convert between Celsius and Kelvin temperature scales is given by

$$K = C + 273$$

The equation to convert between Celsius and Fahrenheit temperature scales is given by

$$F = 1.8\,C + 32$$

Thermometers and its classifications

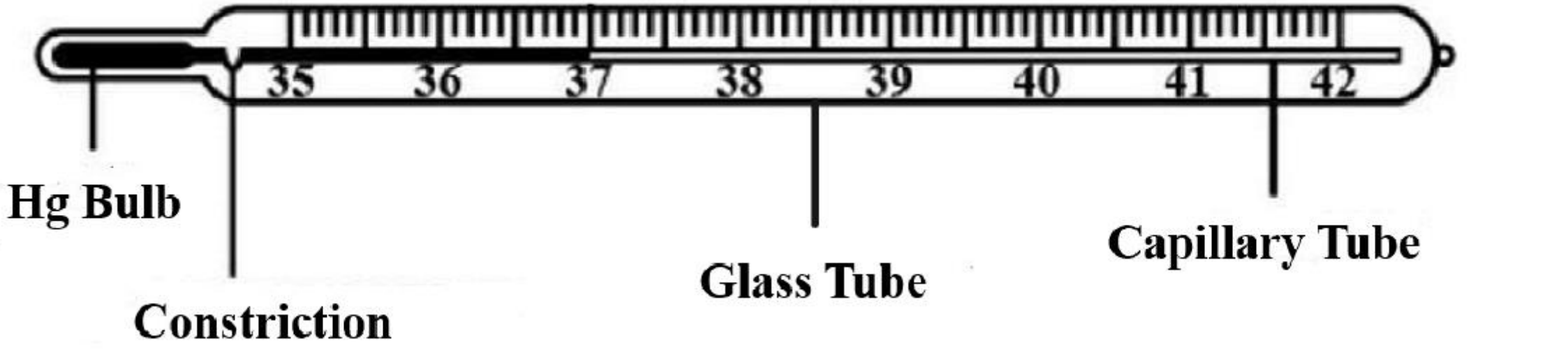
- A thermometer is a device used to measure temperature. The science of measuring temperature is known as thermometry.
- According to its measurement principles, thermometers are classified into different categories as listed below:

1. The liquid in the glass thermometer (Mercury thermometer, alcohol thermometer, etc.)
2. Constant volume gas thermometer
3. Constant pressure gas thermometer
4. Resistance thermometer
5. Thermoelectric thermometer or Thermocouple
6. Pyrometers
7. Silicon diode thermometer
8. Bimetallic thermometer

Mercury Thermometer

- It is the common thermometer used in laboratories principle of thermal expansion of liquids. The thermometer consists of a very fine glass tube having a very small bore (capillary tube) thin glass bulb at one end as shown in the figure.
- The bulb is filled with mercury. The other end of the capillary tube is sealed. The capillary tube is protected by a thick glass tube called on the stem.
- These markings are called graduations or degrees. As the glass bulb and the liquid are heated, the volume of both glass tube and mercury increase with temperature. The mercury expands more than glass. Hence, the liquid level rises with the increase in temperature and falls when the temperature is lowered. The practical range of mercury thermometers is -30^0C to 250^0C.

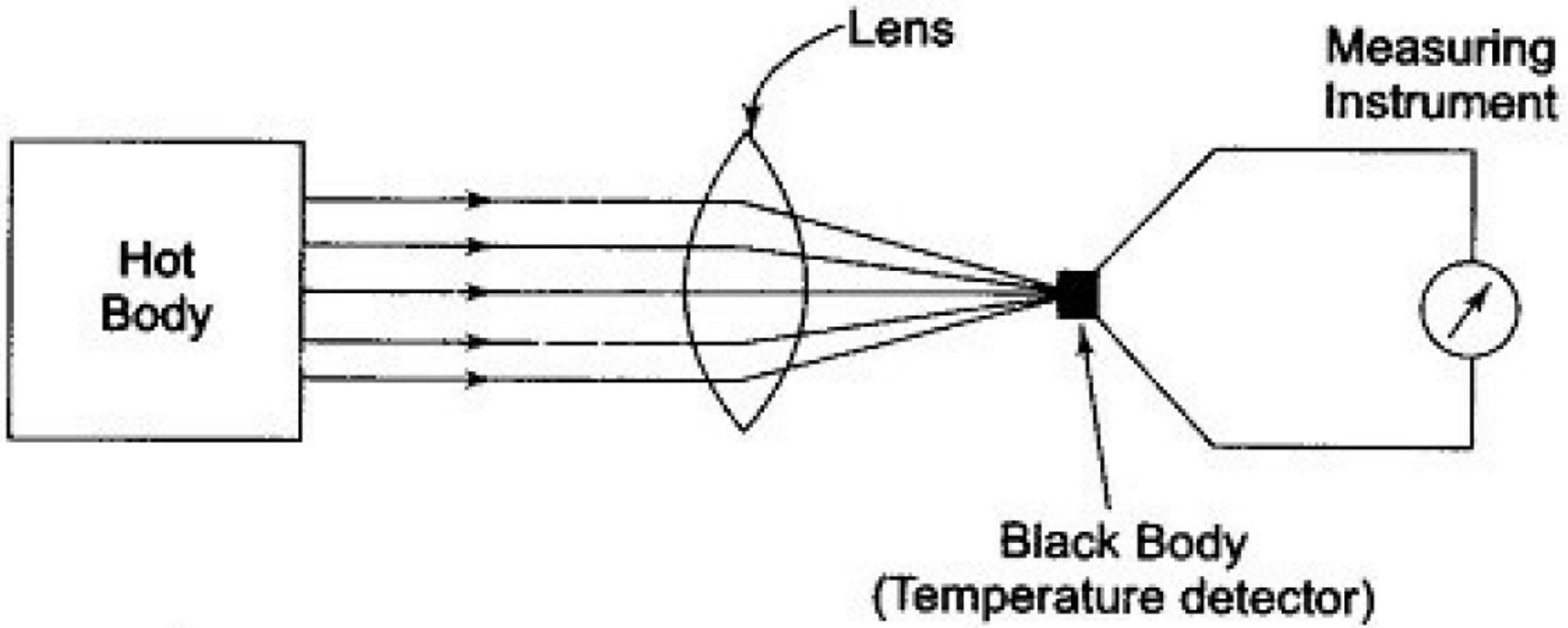
Schematic diagram of Mercury Thermometer



Pyrometers

- The name pyrometer is given to those thermometers which are used for measuring temperatures above 500^0C. The familiar pyrometers are total radiation pyrometers and optical pyrometers.
- A pyrometer, also known as an non-contact thermometer is used to detect the temperature of an which depends on the radiation (infrared or visible) emitted from the object.
- Pyrometers act as photo detectors because of the property of absorbing energy and measuring EM wave intensity at any wavelength.
- A pyrometer is useful for measuring moving, extremely hot or hard to reach objects.
- The basic principle of the pyrometer is that it measures the object's temperature by sensing the heat radiation emitted from the object without making contact with the object. It records the temperature level depending upon the intensity of radiation emitted. The pyrometer has two basic components like optical systems and detectors that are used to measure the surface temperature of the object.

Schematic diagram of a pyrometer



Infrared pyrometers are made up of pyroelectric materials like polyvinylidene fluoride (PVDF),

triglycine sulfate (TGS), and lithium tantalate ($LiTaO_3$).

- This radiation can be directed to a thermocouple to convert into electrical signals.

The advantages of pyrometer are

a) It can measure the temperature of the object without any contact with the object. This is called non-contact measurement.

b) It has a fast response time.

c) Good stability while measuring the temperature of the object.

d) It can measure the temperature of different types of objects at variable distances.

Applications of Pyrometer

1) To measure the temperature of moving objects or constant objects from a greater distance.
2) In metallurgy industries
3) In smelting industries
4) Hot air balloons to measure the heat at the top of the balloon.
5) Steam boilers to measure steam temperature
6) To measure the temperature of liquid metals and highly heated materials.
7) To measure furnace temperature