

JSR IAS ACADEMY

GENERAL SCIENCE
PHYSICS
HEAT- 1

Heat

- ❖ Heat is an energy that raises the temperature of a thing by causing the molecules in that thing to move faster.
- ❖ SI Unit of Heat is joule.
- ❖ The unit calorie is also used.

Temperature

- ❖ The measurement of warmness or coldness of a substance is known as its Temperature.
- ❖ SI unit of temperature is kelvin.
- ❖ Celsius and Fahrenheit are the other units used.
- ❖ the room temperature of water is approximately 30°C

Heat and Temperature

Heat and temperature are not the same thing, they in fact mean two different things:

- ❖ Temperature measures the average kinetic energy of molecules.
- ❖ Heat measures the total kinetic energy of the molecules in the substance.

Calorie

- ❖ One calorie is the amount of heat energy required to raise the temperature of 1 gram of water through 1°C.
- ❖ The relation between calorie and joule is given as, 1 calorie = 4.186 J.



The amount of energy in food items is measured by the unit kilo calorie.

1 kilo calorie = 4200 J (Approximately).

Temperature Units:

There are three units which are used to measure the temperature:

1. Degree Celsius,
2. Fahrenheit
3. Kelvin.

Degree Celsius:

- ❖ Celsius is written as °C and read as degree.
- ❖ Celsius is called as Centigrade as well.
- ❖ Celsius is the common unit of measuring temperature, termed after Swedish astronomer, **Anders Celsius** in 1742,
- ❖ before that it was known as Centigrade as thermometers using this scale are calibrated

from (Freezing point of water) 0°C to 100°C (boiling point of water).

- ❖ In Greek, 'Centium' means 100 and 'Gradus' means steps, both words make it centigrade and later Celsius.
- ❖ Interval has been divided into 100 parts

Fahrenheit:

- ❖ Fahrenheit is written as °F for example 25°F
- ❖ Fahrenheit is a Common unit to measure human body temperature.
- ❖ It is termed after the name of a German Physicist **Daniel Gabriel Fahrenheit**.
- ❖ Freezing point of water is taken as 32°F and boiling point 212°F.
- ❖ Interval has been divided into 180 parts.
- ❖ The formula to convert a Celsius scale to Fahrenheit scale is:

$$F = \frac{9}{5} C + 32$$

The formula for converting a Fahrenheit scale to Celsius scale is:

$$C = \frac{5}{9} (F - 32)$$

Kelvin:

- ❖ Kelvin is written as K.
- ❖ The SI unit of temperature is kelvin (K).
- ❖ Kelvin scale is termed after **Lord Kelvin**.
- ❖ It is the SI unit of measuring temperature and written as K also known as absolute scale as it starts from absolute zero temperature.
- ❖ On the Kelvin scale 0 K represents absolute zero, the temperature at which the molecules of a substance have their lowest possible energy.
- ❖ The solid, liquid, gaseous phases of water can coexist in equilibrium at 273.16 K.
- ❖ Kelvin is defined as 1/273.16 of the triple point temperature.
- ❖ The formula for converting a Celsius scale to Kelvin scale is: $K = C + 273.15$

Absolute zero

- ❖ The temperature at which the pressure and volume of a gas theoretically reaches zero is called absolute zero.
- ❖ For all gases, the pressure extrapolates to zero at the temperature -273.15 °C. It is known as absolute zero or 0 K.

Relation between Fahrenheit scale and Celsius scales is as under.

$$\frac{(F-32)}{9} = \frac{C}{5}, \quad K = 273.15 + C$$

The equivalence between principal temperature scales are given in Table for some temperatures.

Temperature	Celsius scale (°C)	Fahrenheit scale (°F)	Kelvin scale (K)
Boiling point of water	100	212	373.15
Freezing point of water	0	32	273.15
Mean temperature of human body	37	98.6	310.15
Room temperature (Average)	72	23	296.15

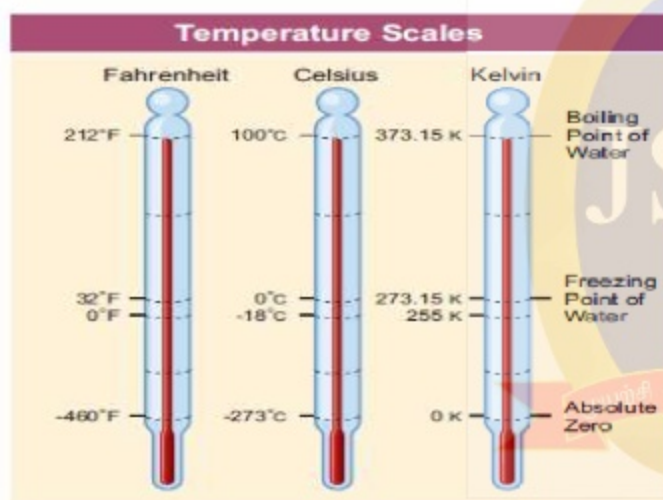


Figure 7.6 Types of temperature scales



Solved examples

1. How much will the temperature of 68°F be in Celsius and Kelvin?

Given :

$$\text{Temperature in Fahrenheit} = F = 68^{\circ}\text{F}$$

$$\text{Temperature in Celsius} = C = ?$$

$$\text{Temperature in Kelvin} = K = ?$$

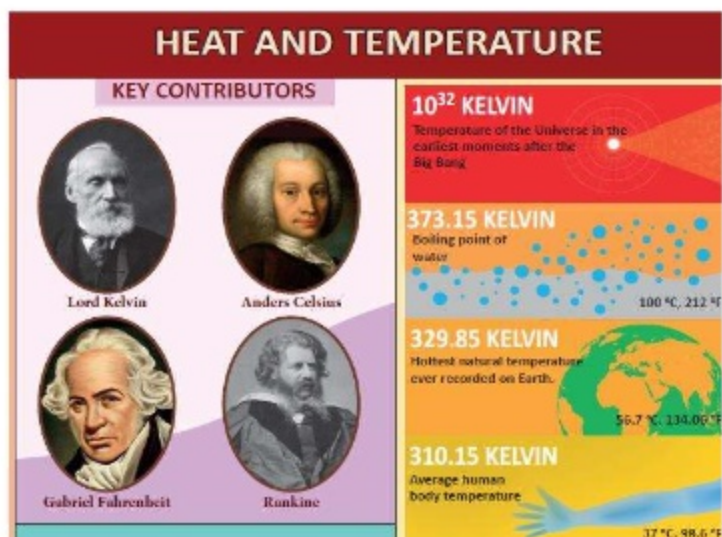
$$\frac{(F-32)}{9} = \frac{C}{5}$$

$$\frac{(68-32)}{9} = \frac{C}{5}$$

$$C = 5 \times \frac{36}{9} = 20^{\circ}\text{C}$$

$$K = C + 273.15 = 20 + 273.15 = 293.15$$

Thus, the temperature in Celsius = 20°C
and in Kelvin = 293.15 K



2. At what temperature will its value be same in Celsius and in Fahrenheit?

Given : If the temperature in Celsius is C, then the temperature in Fahrenheit (F) will be same,

$$\begin{aligned} \text{i.e. } F &= C, \quad \frac{(F-32)}{9} = \frac{C}{5} \\ (\text{or}) \\ \frac{(C-32)}{9} &= \frac{C}{5} \\ (C-32) \times 5 &= C \times 9 \\ 5C - 160 &= 9C \\ 4C &= -160 \\ C &= F = -40 \end{aligned}$$

The temperatures in Celsius and in Fahrenheit will be same at -40

Problem 1

Convert the following

- i. 25°C to Kelvin ii. 200 K to $^{\circ}\text{C}$

Solution:

- i. $T_K = T_{^{\circ}\text{C}} + 273.15$
 $T_K = 25 + 273.15 = 298.15\text{ K}$
 ii. $T_{^{\circ}\text{C}} = T_K - 273.15$
 $T_{^{\circ}\text{C}} = 200 - 273.15 = -73.15^{\circ}\text{C}$

Problem 2

Convert the following

- i. 35°C to Fahrenheit ($^{\circ}\text{F}$) ii. 14°F to $^{\circ}\text{C}$

Solution:

- i. $T_{^{\circ}\text{F}} = T_{^{\circ}\text{C}} \times 1.8 + 32$
 $T_{^{\circ}\text{F}} = 35^{\circ}\text{C} \times 1.8 + 32 = 95^{\circ}\text{F}$
 ii. $T_{^{\circ}\text{C}} = (T_{^{\circ}\text{F}} - 32) / 1.8$
 $T_{^{\circ}\text{C}} = (14^{\circ}\text{F} - 32) / 1.8 = -10^{\circ}\text{C}$

Thermometer:

Thermometer is the most common instrument to measure temperature.

Why Mercury or Alcohol is used in Thermometer?

- ❖ Mostly Alcohol and Mercury are used in thermometers as they remain in liquid form even with a change of temperature in them.

- ❖ A small change in the temperature causes change in volume of a liquid.
- ❖ We measure this temperature by measuring expansion of a liquid in thermometer.

Properties of Mercury:-

- ❖ Its expansion is uniform. (For equal amounts of heat it expands by equal lengths.)
- ❖ It is opaque and shining.
- ❖ It does not stick to the sides of the glass tube.
- ❖ It is a good conductor of heat.
- ❖ It has a high boiling point (357°C) and a low freezing point (-39°C). Hence a wide range of temperatures can be measured using a mercury thermometer

Properties of Alcohol

- ❖ The freezing point of alcohol is less than -100°C . So it can be used to measure very low temperatures.
- ❖ Its expansion per degree Celsius rise in temperature is very large.
- ❖ It can be coloured brightly and hence is easily visible.

Types of Thermometers

Clinical Thermometer

- ❖ These thermometers are used to measure the temperature of a human body, at home, clinics and hospitals.
- ❖ All clinical thermometers have a kink that prevents the mercury from flowing back into the bulb when the thermometer is taken out of the patient's mouth, so that the temperature can be noted conveniently.
- ❖ There are temperature scales on either side of the mercury thread, one in Celsius scale and the other in Fahrenheit scale.
- ❖ Since the Fahrenheit scale is more sensitive than the Celsius scale, body temperature is measured in F only.
- ❖ A clinical thermometer indicates temperatures from a minimum of 35°C or 94°F to a maximum of 42°C or 108°F .

Precautions to be Followed While Using a Clinical Thermometer

- ❖ The thermometer should be washed before and after use, preferably with an antiseptic solution.
- ❖ Jerk the thermometer a few times to bring the level of the mercury down. Before use, the mercury level should be below 35°C or 94°F .
- ❖ Do not hold the thermometer by its bulb.
- ❖ Keep the mercury level along your line of sight and then take the reading.
- ❖ Handle the thermometer with care. If it hits against some hard object, it may break.
- ❖ Do not place the thermometer in a hot flame or in the hot sun.

Laboratory Thermometers

- ❖ Laboratory thermometers are used to measure the temperature in school and other laboratories for scientific research.

- ❖ They are also used in the industry as they can measure temperatures higher than what clinical thermometers can record.
- ❖ The stem and the bulb of a lab thermometer are longer when compared to that of a clinical thermometer and there is no kink in the lab thermometer.
- ❖ A laboratory thermometer has only the Celsius scale ranging from -10°C to 110°C .

Precautions to be Followed While Using a Laboratory Thermometer

- ❖ Do not tilt the thermometer while measuring the temperature. Place it upright.
- ❖ Note the reading only when the bulb has been surrounded by the substance from all sides.

Difference between clinical and laboratory thermometer

Clinical Thermometer	Laboratory Thermometer
Clinical thermometer is scaled from 35°C to 42°C or from 94°F to 108°F .	Laboratory thermometer is generally scaled from -10°C to 110°C .
Mercury level does not fall on its own, as there is a kink near the bulb to prevent the fall of mercury level.	Mercury level falls on its own as no kink is present.
Temperature can be read after removing the thermometer from armpit or mouth.	Temperature is read while keeping the thermometer in the source of temperature, e.g. a liquid or any other thing.
To lower the mercury level jerks are given.	No need to give jerk to lower the mercury level.
It is used for taking the body temperature.	It is used to take temperature in laboratory.

DO YOU KNOW?

In humans, the average internal temperature is 37°C (98.6°F), though it varies among individuals.

However, no person always has exactly the same temperature at every moment of the day. Temperatures cycle regularly up and down through the day according to activities and external factors.

Digital Thermometer

- ❖ Mercury is a toxic substance and is very difficult to dispose of if a thermometer breaks.
- ❖ These days, digital thermometers are available which do not use mercury.
- ❖ Instead, it has a sensor which can measure the heat coming out from the body directly and from that can measure the temperature of the body.

DO
YOU
KNOW?

Most of the people in the world use the Celsius scale to measure temperature for day to day purpose. The Kelvin scale has been designed in such a way, it is not only an absolute temperature scale, but also 1°C change is equal to a 1K change. This makes the conversion from Celsius to absolute temperature scale (Kelvin scale) easy, just the addition or subtraction of a constant 273.15

But in United States they prefer to use the Fahrenheit scale. The problem is, converting Fahrenheit to absolute scale (Kelvin) is not easy.

To sort out this problem they use The Rankine scale. It named after the Glasgow University engineer and physicist **Rankine**, who proposed it in 1859. It is an absolute temperature scale, and has the property of having a 1°R change is equal to a 1°F change. Fahrenheit users who need to work with absolute temperature can be converted to Rankine by

$$R = F + 459.67$$

