

the glass tumbler, whereas in the case of hot tea, it flows from the cup of hot tea to the environment. So, we can say that **heat is the form of energy transferred between two (or more) systems or a system and its surroundings by virtue of temperature difference.** The SI unit of heat energy transferred is expressed in joule (J) while SI unit of temperature is Kelvin (K), and degree Celsius ($^{\circ}\text{C}$) is a commonly used unit of temperature. When an object is heated, many changes may take place. Its temperature may rise, it may expand or change state. We will study the effect of heat on different bodies in later sections.

11.3 MEASUREMENT OF TEMPERATURE

A measure of temperature is obtained using a thermometer. Many physical properties of materials change sufficiently with temperature. Some such properties are used as the basis for constructing thermometers. The commonly used property is variation of the volume of a liquid with temperature. For example, in common liquid-in-glass thermometers, mercury, alcohol etc., are used whose volume varies linearly with temperature over a wide range.

Thermometers are calibrated so that a numerical value may be assigned to a given temperature in an appropriate scale. For the definition of any standard scale, two fixed reference points are needed. Since all substances change dimensions with temperature, an absolute reference for expansion is not available. However, the necessary fixed points may be correlated to the physical phenomena that always occur at the same temperature. The ice point and the steam point of water are two convenient fixed points and are known as the freezing and boiling points, respectively. These two points are the temperatures at which pure water freezes and boils under standard pressure. The two familiar temperature scales are the Fahrenheit temperature scale and the Celsius temperature scale. The ice and steam point have values 32°F and 212°F , respectively, on the Fahrenheit scale and 0°C and 100°C on the Celsius scale. On the Fahrenheit scale, there are 180 equal intervals between two reference points, and on the Celsius scale, there are 100.

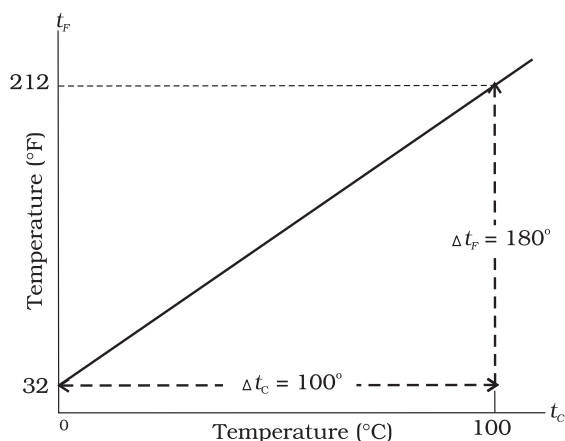


Fig. 11.1 A plot of Fahrenheit temperature (t_F) versus Celsius temperature (t_C).

A relationship for converting between the two scales may be obtained from a graph of Fahrenheit temperature (t_F) versus Celsius temperature (t_C) in a straight line (Fig. 11.1), whose equation is

$$\frac{t_F - 32}{180} = \frac{t_C}{100} \quad (11.1)$$

11.4 IDEAL-GAS EQUATION AND ABSOLUTE TEMPERATURE

Liquid-in-glass thermometers show different readings for temperatures other than the fixed points because of differing expansion properties. A thermometer that uses a gas, however, gives the same readings regardless of which gas is used. Experiments show that all gases at low densities exhibit same expansion behaviour. The variables that describe the behaviour of a given quantity (mass) of gas are pressure, volume, and temperature (P , V , and T) (where $T = t + 273.15$; t is the temperature in $^{\circ}\text{C}$). When temperature is held constant, the pressure and volume of a quantity of gas are related as $PV = \text{constant}$. This relationship is known as Boyle's law, after Robert Boyle (1627–1691), the English Chemist who discovered it. When the pressure is held constant, the volume of a quantity of the gas is related to the temperature as $V/T = \text{constant}$. This relationship is known as Charles' law, after French scientist Jacques Charles (1747–1823). Low-density gases obey these laws, which may be combined into a single