03. Temperatur dan panas

Temperature

- Salah satu kuantitas/besaran dasar SI

$$T(\mathrm{K}) = T(^{\circ}\mathrm{C}) + 273.15$$

$$T(^{\circ}\mathrm{R}) = T(^{\circ}\mathrm{F}) + 459.67$$

$$T(^{\circ}\mathrm{R}) = 1.8T(\mathrm{K})$$

$$T(^{\circ}\mathrm{F}) = 1.8T(^{\circ}\mathrm{C}) + 32$$

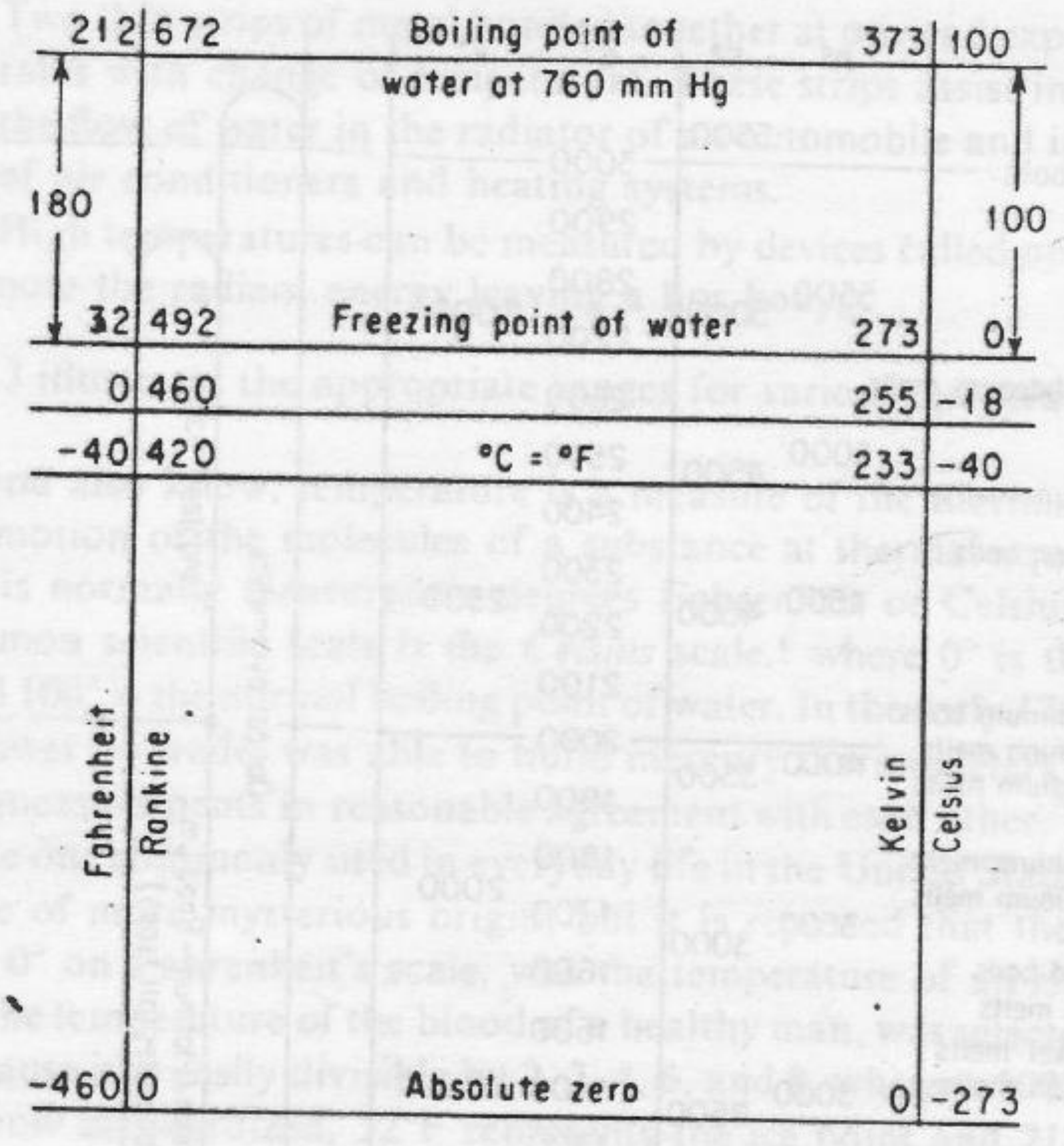
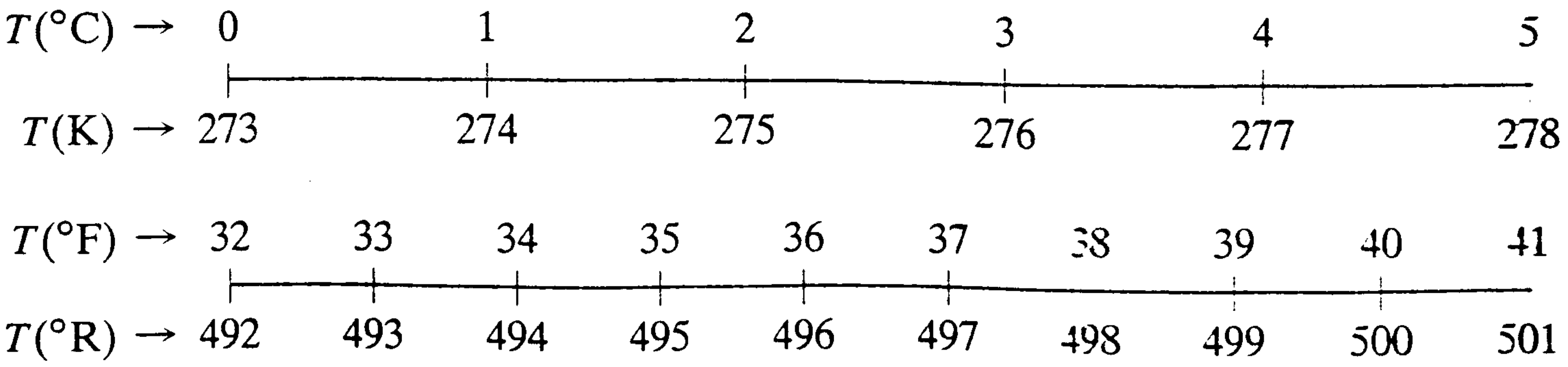
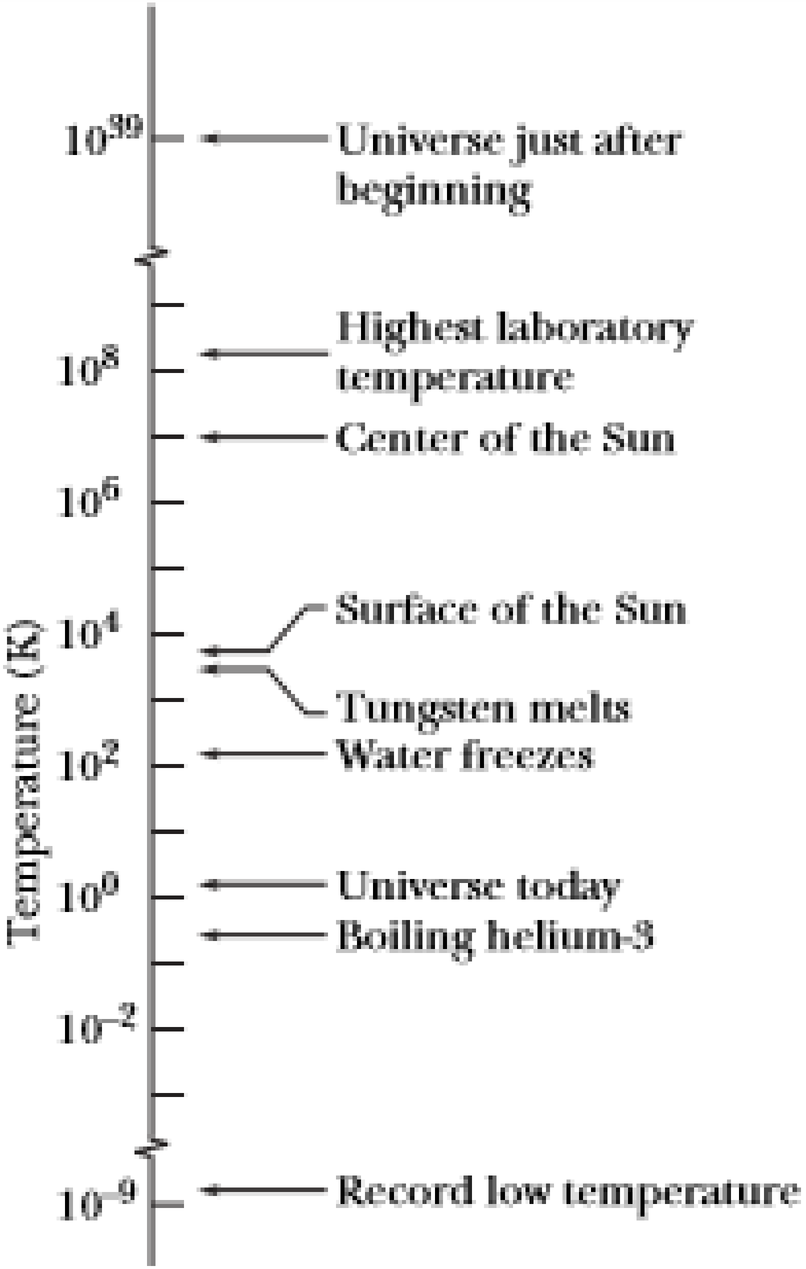


Fig. 1.4. Temperature scales.

A degree is both a temperature and a temperature interval, a fact that sometimes leads to confusion. Consider the temperature interval from 0°C to 5°C. There are nine Fahrenheit and nine Rankine degrees in this interval, and only five Celsius degrees and five Kelvin. An interval of 1 Celsius degree or Kelvin therefore contains 1.8 Fahrenheit or Rankine degrees, leading to the conversion factors

$$\frac{1.8°\text{F}}{1°\text{C}}, \frac{1.8°\text{R}}{1\ \text{K}}, \frac{1°\text{F}}{1°\text{R}}, \frac{1°\text{C}}{1\ \text{K}} \tag{3.5-5}$$

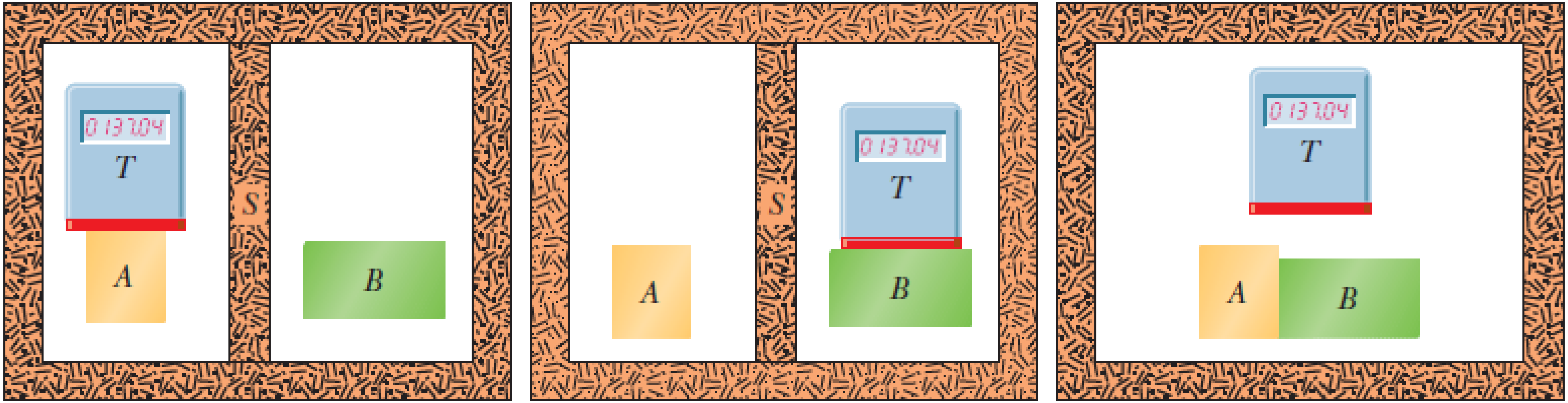



Temperature (K)
10^{39}
10^8
10^6
10^4
10^2
10^0
10^{-2}
10^{-9}
Universe just after beginning
Highest laboratory temperature
Center of the Sun
Surface of the Sun
Tungsten melts
Water freezes
Universe today
Boiling helium-3
Record low temperature

Hukum ke-nol termodinamika

Setiap benda memiliki suhu.

Apabila benda A dan B masing-masing berada pada kesetimbangan suhu dengan benda ketiga T, maka benda A dan B berada dalam kesetimbangan suhu satu sama lain.



0 137.04
T
S
A
B

Pengukuran suhu

The Triple Point of Water

ditetapkan pada 273.16 K sebagai standar kalibrasi penetapan skala termometer

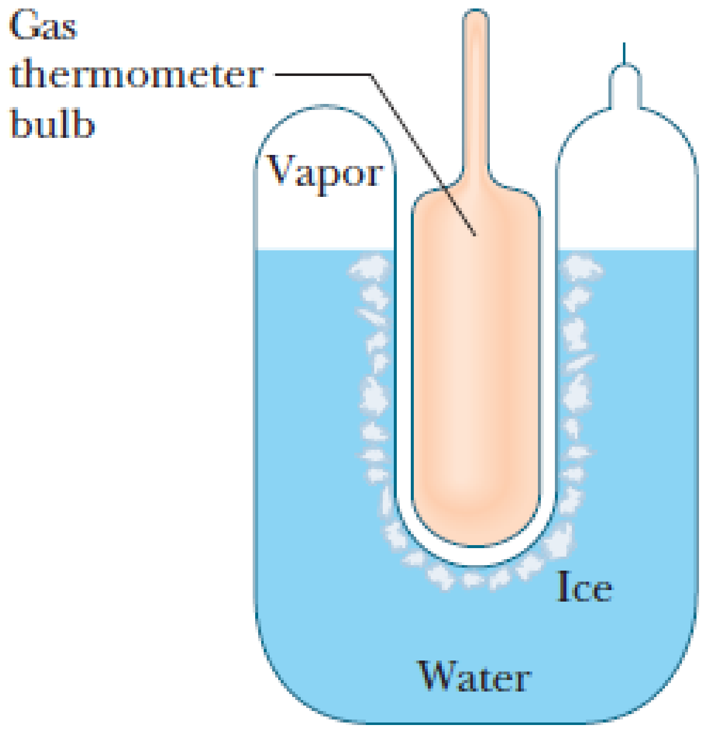
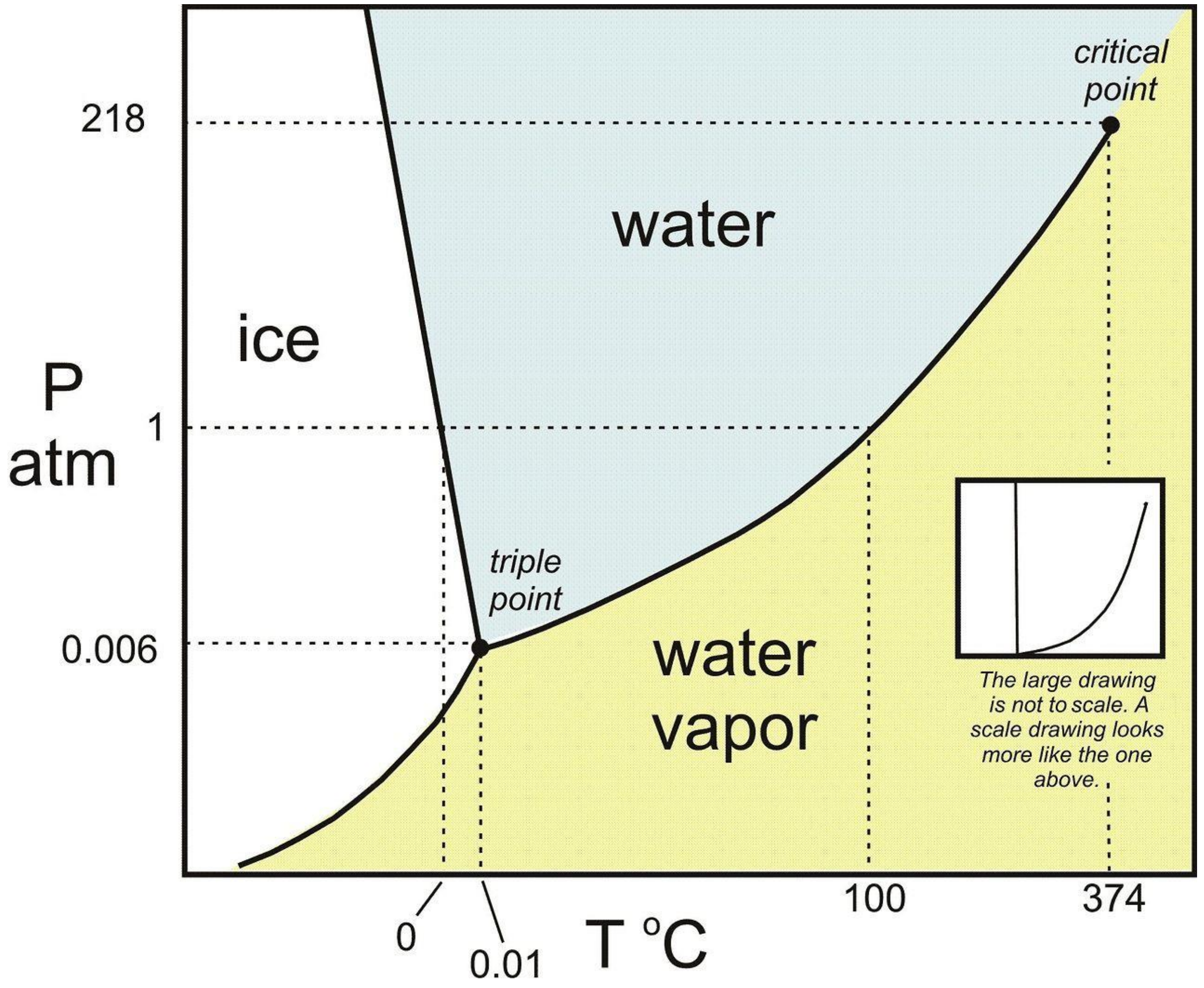


Figure 18-4 A triple-point cell, in which solid ice, liquid water, and water vapor coexist in thermal equilibrium. By international agreement, the temperature of this mixture has been defined to be 273.16 K. The bulb of a constant-volume gas thermometer is shown inserted into the well of the cell.



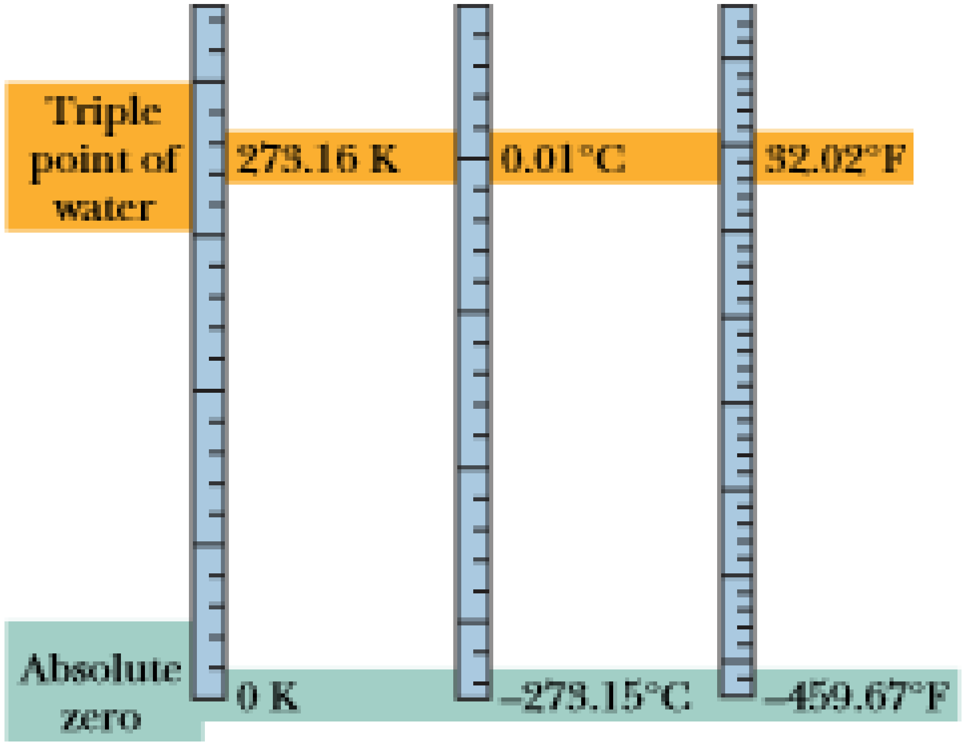


Fig. 18-7 The Kelvin, Celsius, and Fahrenheit temperature scales compared.

Table 18-1

Some Corresponding Temperatures

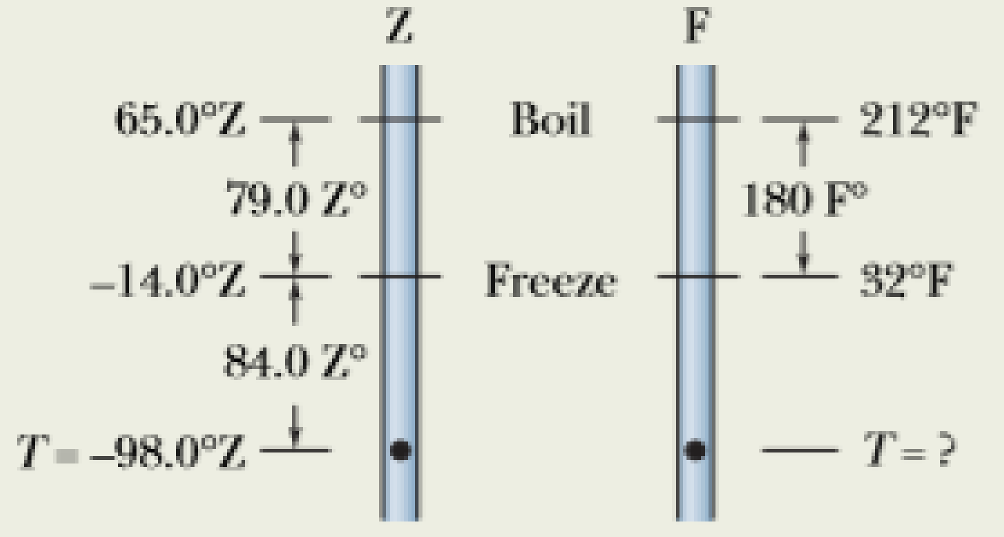
Temperature	°C	°F
Boiling point of water[a]	100	212
Normal body temperature	37.0	98.6
Accepted comfort level	20	68
Freezing point of water[a]	0	32
Zero of Fahrenheit scale	≈ −18	0
Scales coincide	−40	−40

[a]Strictly, the boiling point of water on the Celsius scale is 99.975°C, and the freezing point is 0.00°C. Thus, there is slightly less than 100 C° between those two points.

Example

A pan of water is heated from 25°C to 80°C. What is the change in its temperature on the Kelvin scale and on the Fahrenheit scale?

Suppose you come across old scientific notes that describe a temperature scale called Z on which the boiling point of water is 65.0°Z and the freezing point is −14.0°Z. To what temperature on the Fahrenheit scale would a temperature of $T = -98.0°\text{Z}$ correspond? Assume that the Z scale is linear; that is, the size of a Z degree is the same everywhere on the Z scale.



Now, since T is below the freezing point by 84.0 Z°, it must also be below the freezing point by

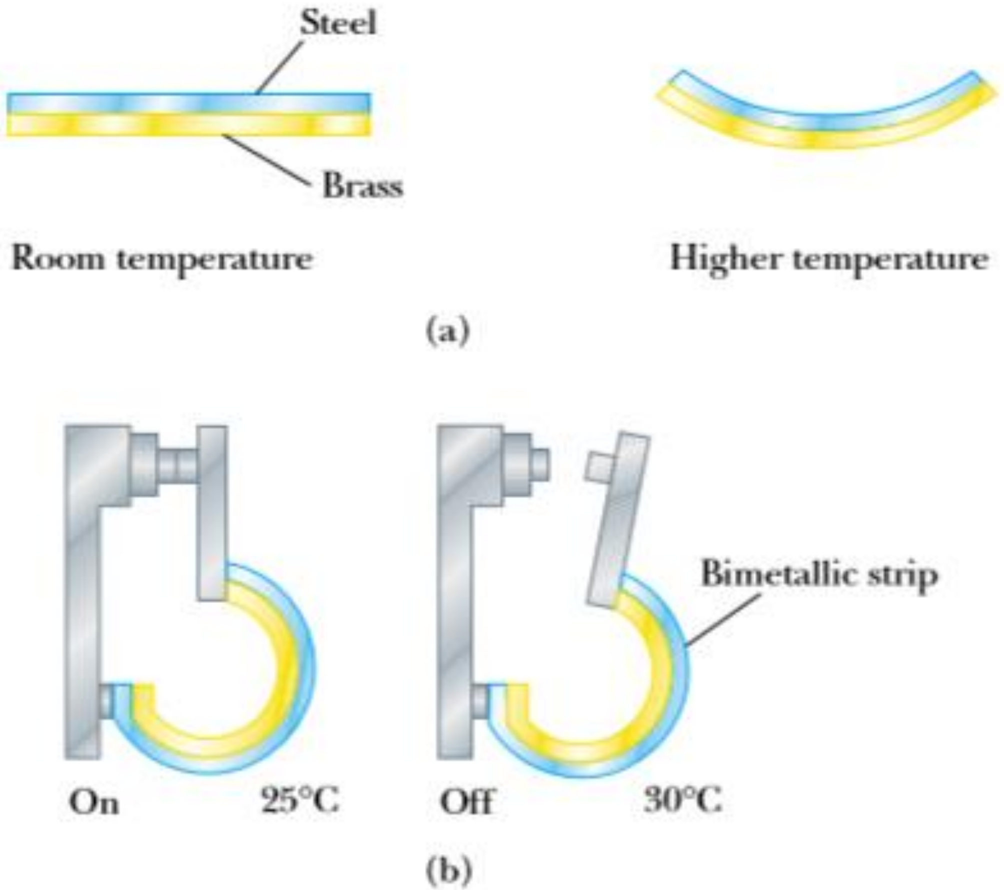
$$(84.0\ \text{Z}^\circ)\frac{180\ \text{F}^\circ}{79.0\ \text{Z}^\circ} = 191\ \text{F}^\circ.$$

Because the freezing point is at 32.0°F, this means that

$$T = 32.0^\circ\text{F} - 191\ \text{F}^\circ = -159^\circ\text{F}. \qquad \text{(Answer)}$$

Thermal Expansion

Linier expansion



$$\Delta L = \alpha L_i \Delta T$$

$$L_f - L_i = \alpha L_i (T_f - T_i)$$

A segment of steel railroad track has a length of 30.000 m when the temperature is 0.0°C.

(A) What is its length when the temperature is 40.0°C?

(B) Suppose that the ends of the rail are rigidly clamped at 0.0°C so that expansion is prevented. What is the thermal stress set up in the rail if its temperature is raised to 40.0°C?

Average Expansion Coefficients for Some Materials Near Room Temperature

Material	Average Linear Expansion Coefficient $(\alpha)(°C)^{-1}$	Material	Average Volume Expansion Coefficient $(\beta)(°C)^{-1}$
Aluminum	24×10^{-6}	Alcohol, ethyl	1.12×10^{-4}
Brass and bronze	19×10^{-6}	Benzene	1.24×10^{-4}
Copper	17×10^{-6}	Acetone	1.5×10^{-4}
Glass (ordinary)	9×10^{-6}	Glycerin	4.85×10^{-4}
Glass (Pyrex)	3.2×10^{-6}	Mercury	1.82×10^{-4}
Lead	29×10^{-6}	Turpentine	9.0×10^{-4}
Steel	11×10^{-6}	Gasoline	9.6×10^{-4}
Invar (Ni–Fe alloy)	0.9×10^{-6}	Air[a] at 0°C	3.67×10^{-3}
Concrete	12×10^{-6}	Helium[a]	3.665×10^{-3}

$$\Delta L = \alpha L_i \, \Delta T = [11 \times 10^{-6} (°C)^{-1}](30.000 \text{ m})(40.0°C)$$
$$= 0.013 \text{ m}$$

If the track is 30.000 m long at 0.0°C, its length at 40.0°C is

30.013 m.

$$\text{Tensile stress} = \frac{F}{A} = Y \frac{\Delta L}{L_i}$$

Y for steel is 20×10^{10} N/m^2

$$\frac{F}{A} = (20 \times 10^{10} \text{ N/m}^2)\left(\frac{0.013 \text{ m}}{30.000 \text{ m}}\right) = 8.7 \times 10^{7} \text{ N/m}^2$$

Hukum gas ideal

$PV = nRT$

P : tekanan gas [=]bar,kPa,psia

V : volume [=]L, m3,cuft

n : mol [=] kmol,lbmol

T : suhu [=] K, R

R : konstanta gas ideal

- R = 8,314 kJ/kmol.K
  = 8,314 kPa.m3/kmol.K
  = 0,08314 bar.m3/kmol.K
  = 1,9859 Btu/mol.R
  = 10,7316 psia.cuft/lbmol.R
  = 1545,37 ft.lbf/lbmol.R
  = 0,08205 L.atm/mol.K

$$p_1V_1 = nRT_1$$
$$p_2V_2 = nRT_2$$

$$\frac{p_1V_1}{p_2V_2} = \frac{T_1}{T_2}$$

- Pada kondisi standar (0 ° C, 1 atm) :

Volume of 1 gram-mole S.C. = 22.41 liters

Volume of 1 pound-mole S.C. = 359 cubic feet

STANDARD CONDITIONS

Temperature	*Pressure*
0°Centigrade	1 atmosphere
273°Kelvin	760 mm of mercury
32°Fahrenheit	29.92 in. of mercury
492°Rankine	14.70 lb per sq in.