

Ch 13. Temperature & Gas Laws

I. Temperature

A measure of how hot /cold an object is

Temperature Scale

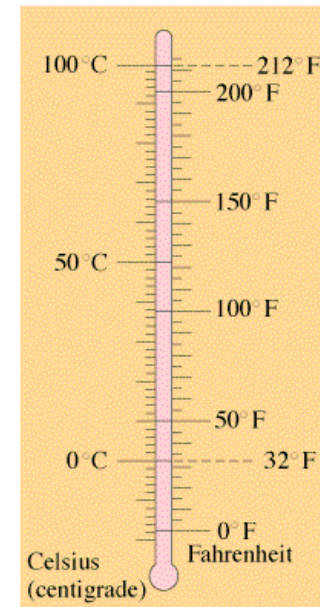
Celsius (centigrade)	°C
Fahrenheit	°F
Absolute (Kelvin, Scientific work)	K

Temperature Conversion

$$T_C = \frac{5}{9} (T_F - 32^\circ)$$

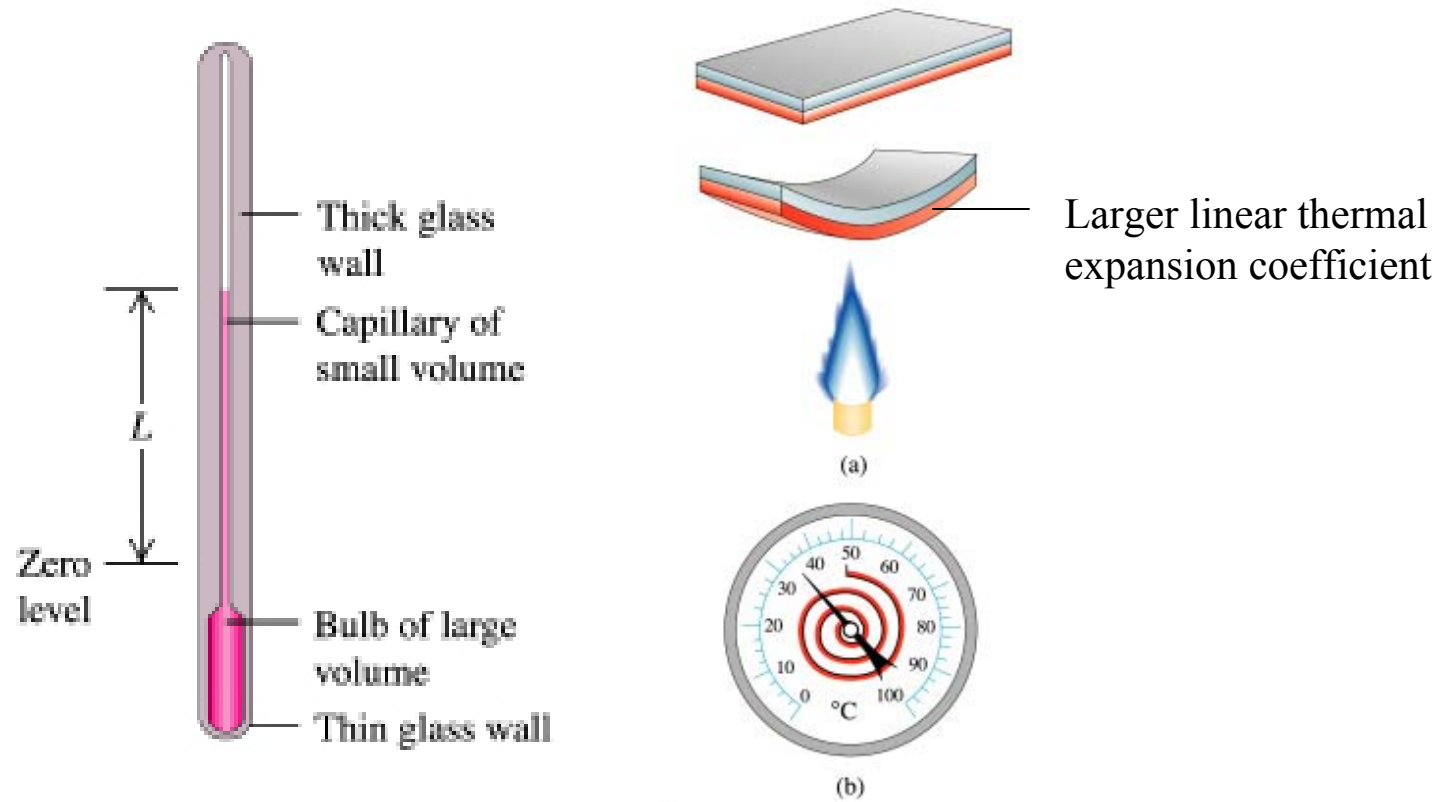
$$T_F = 9 T_C / 5 + 32^\circ$$

$$T_K = T_C + 273.15$$

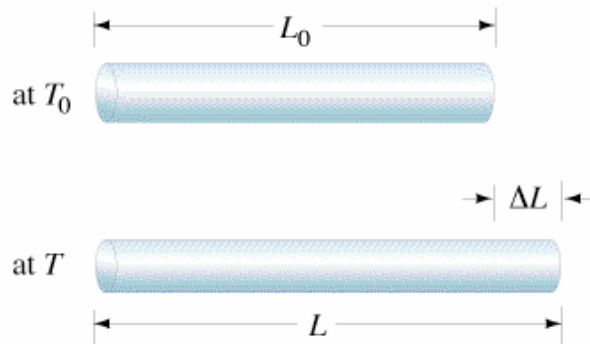


	K	C	F
<u>Water boils</u>	373	100°	212°
	↑ 100 K	↑ 100 C°	↑ 180 F°
<u>Water freezes</u>	273	0°	32°
CO ₂ solidifies	195	-78°	-109°
Oxygen liquifies	90	-183°	-298°
<u>Absolute zero</u>	0	-273°	-460°

Thermometer



II. Thermal Expansion



Most substances:

Expand when heated

Contract when cooled

$$\frac{\Delta L}{L_0} = \alpha \Delta T \quad L = L_0 (1 + \alpha \Delta T)$$

α – Coefficient of linear expansion

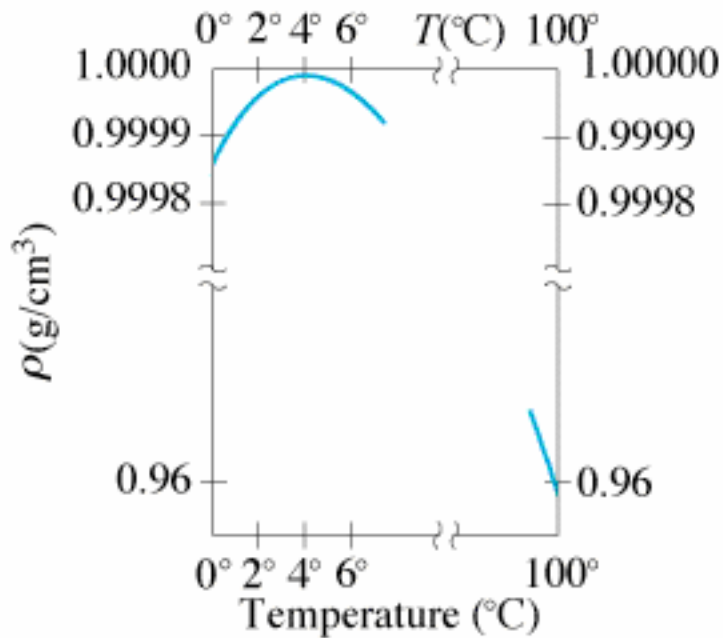
$$\frac{\Delta V}{V_0} = \beta \Delta T$$

β – Coefficient of volume expansion

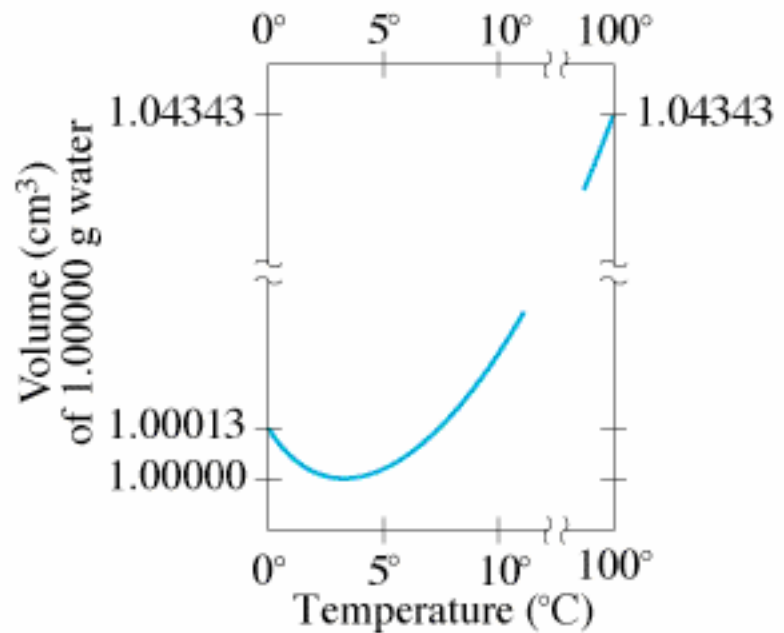
Glass, $\beta \sim 10^{-5}/\text{C}^\circ$

Mercury, $\beta \sim 10^{-4}/\text{C}^\circ$

Anomalous Behavior of Water Below 4°C



(a)



(b)

Water expands as it cools from 4°C to 0°C, expands more upon freezing. In a pool of water, it freezes from **top**.

III. Ideal Gas Law

Unified atomic mass unit (u)

^{12}C atom has exactly 12u

$$1\text{u} = 1.66 \times 10^{-27} \text{ kg}$$

Atomic / molecular mass (Periodic table in the back of textbook)

H atoms	1u
H ₂ molecules	2u
N ₂ molecules	28u
O ₂ molecules	32u
CO ₂ molecules	44u

Equilibrium state:

system variables uniform in space & not changing w/ time

$$PV = n_{mole} RT$$

Pressure P

Volume V

Temperature T

Universal Gas Constant $R=8.315 \text{ J}/(\text{mol}\cdot\text{K})$

Mole number $n_{mole} = \text{mass (gram)}/\text{Molecular mass (g/mol)}$

1 mole = amount of substance that contains as many atoms or molecules as there are in 12 grams of ^{12}C .

Specific Cases

At constant T

$$PV = \text{constant}$$

Boyle's law

$$P_1 V_1 = P_2 V_2$$

At constant P

$$V \propto T$$

Charles's law

$$V_1/V_2 = T_1/T_2$$

At constant V

$$P \propto T$$

Gay-Lussac's law

$$P_1/P_2 = T_1/T_2$$

General

$$PV/T = \text{constant}$$

$$P_1 V_1 / T_1 = P_2 V_2 / T_2$$

Standard Temperature & Pressure (STP): 0°C

$$1 \text{ atm} = 1.013 \times 10^5 \text{ N/m}^2 = 1.013 \times 10^5 \text{ Pa}$$

Avogadro's Number

Avogadro's hypothesis:

Equal volumes of gas at the same P and T contain equal number of molecules.

Number of molecules in 1 mole:

$$N_A = 6.02 \times 10^{23}$$

Ideal Gas law: $PV = nRT$

$$\begin{aligned} &= (N/N_A)RT \\ &= N(R/N_A)T \\ &= Nk_B T \end{aligned}$$

Boltzmann's constant

$$k_B = R/N_A = 1.38 \times 10^{-23} \text{ J/K}$$