Chapter 1

Thermal equilibrium – state when the macroscopic variables of two objects stop changing

→ achieved by an exchange of energy ← claim

temperature – is a measure of the tendency of an object to spontaneously give up energy

How do we measure temperature?

- volume (constant pressure) (mercury/alcohol)
- pressure (constant volume)
- electrical resistance
- thermal emf (thermocouple)
- radiation

HW#1 | 1, 2, 7

1.) $C_0 = 0 \quad F_0 = 32$

$C_1 = 100 \quad F_1 = 212$

$C = mF + b$

$0 = m \cdot 32 + b \quad \Big| \quad 100 = m(212) + b$

$m = \frac{5}{9} \qquad b = 32$

7.) $\beta = \frac{\Delta V / V}{\Delta T} \rightsquigarrow$ fractional change in volume $\propto$ change in temp

$\frac{V_f - V_i}{V_i} = \frac{\Delta V}{V} = \beta \cdot \Delta T$

(a) estimate mercury bulb volume $\rightsquigarrow$ cylinder diameter

$\left(\frac{1}{4}\text{ cm diameter}\right)^3 \approx \frac{1}{64} cm^3 \cdot \frac{10^3 mm^3}{1 cm^3} = \underbrace{10 mm^3 = V}$

≈ 100

ΔV from $1°C$

8] $\frac{\Delta L}{L} = \alpha \cdot \Delta T$ $T_F = 100°F$ $T_c = 10°F$ $\Delta T_F = 90°F$

$\frac{\Delta T_F}{\Delta T_c} = \frac{9}{5}$ $\frac{\Delta T_c}{\Delta T_F} = \frac{5}{9}$

(a) $\alpha = 1.1 \cdot 10^{-5} K^{-1}$

$\Delta T_c = \frac{5}{\cancel{9}}(\cancel{90}^{10}°F)$

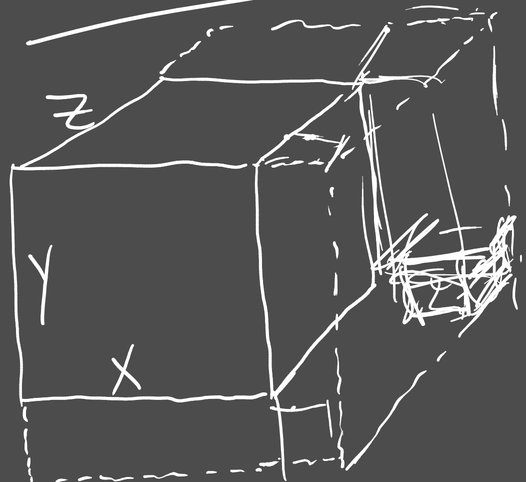
$\Delta L = \alpha \Delta T \cdot L$

$= 1.1 \cdot 10^{-5} \cdot 50°C \cdot 1000\ m$

$\Delta T_c = 50°C$

$= 50000 \cdot 10^{-5}$

$L = .5\ m$

(c) 

$\alpha \Delta T = \frac{\Delta L}{L}$

$\alpha_x \Delta T = \frac{\Delta x}{X}$, $\alpha_y \Delta T = \frac{\Delta y}{Y}$, $\alpha_z \Delta T = \frac{\Delta z}{Z}$

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

$\Delta V = V_f - V_i = (X + \Delta x)(Y + \Delta y)(Z + \Delta z) - XYZ$

$\Delta V = (XY + Y\Delta x + X\Delta y + \Delta x \Delta y)(Z + \Delta z) - XYZ$

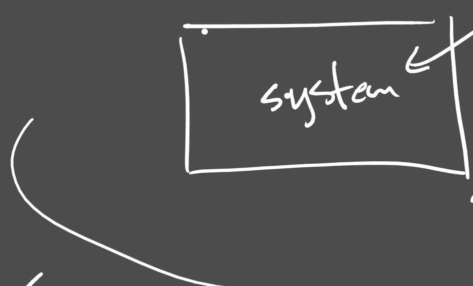
$\Delta V = \cancel{XYZ} + XY\Delta z + YZ\Delta x + Y\Delta x \Delta z + XZ\Delta y + X\Delta y \Delta z + Z\Delta x \Delta y + \Delta x \Delta y \Delta z - \cancel{XYZ}$

$$\beta \Delta T = \frac{\Delta V}{V} = \frac{\Delta V}{XYZ} = \underbrace{\frac{\Delta z}{z}}_{\alpha_z \Delta T} + \underbrace{\frac{\Delta x}{x}}_{\alpha_x \Delta T} + \cancel{\frac{\Delta x \Delta z}{xz}}^{\approx 0} + \underbrace{\frac{\Delta y}{y}}_{\alpha_y \Delta T} + \cancel{\frac{\Delta y \Delta z}{yz}}^{\approx 0} + \cancel{\frac{\Delta x \Delta y}{xy}}^{\approx 0} + \cancel{\frac{\Delta x \Delta y \Delta z}{xyz}}^{\approx 0}$$

$V \leftarrow XYZ$

$$\beta \cancel{\Delta T} = (\alpha_x + \alpha_y + \alpha_z)\cancel{\Delta T}$$

Macroscopic View



what we want to consider

Surroundings

boundary – can be open or closed to matter or energy

Goal: 1. describe the behavior of system
2. describe interactions w/ surroundings
3. BOTH!

Macroscopic description: variables at human scale or larger
↳ easy to measure in a lab

Microscopic description: variables at molecular scale or smaller
↳ very hard to measure directly

Take a cylinder of a gas: (what does it take to describe it)

- mass + composition
- volume
- pressure
- temperature

these form macroscopic coordinates

1. no special assumptions about structure of matter
2. fewest possible to provide description
3. fundamental → suggested by sensory perception.
4. directly measurable

Microscopic view treated w/ statistical mechanics has nearly the opposite of these conditions

P, V, T $\rightsquigarrow$ two can be varied but third is determined by those

An equation that relates the thermodynamic coordinates
↳ <u>equation</u> of <u>state</u>

for a closed system, the equation of state relates temp to <u>two</u> other variables.