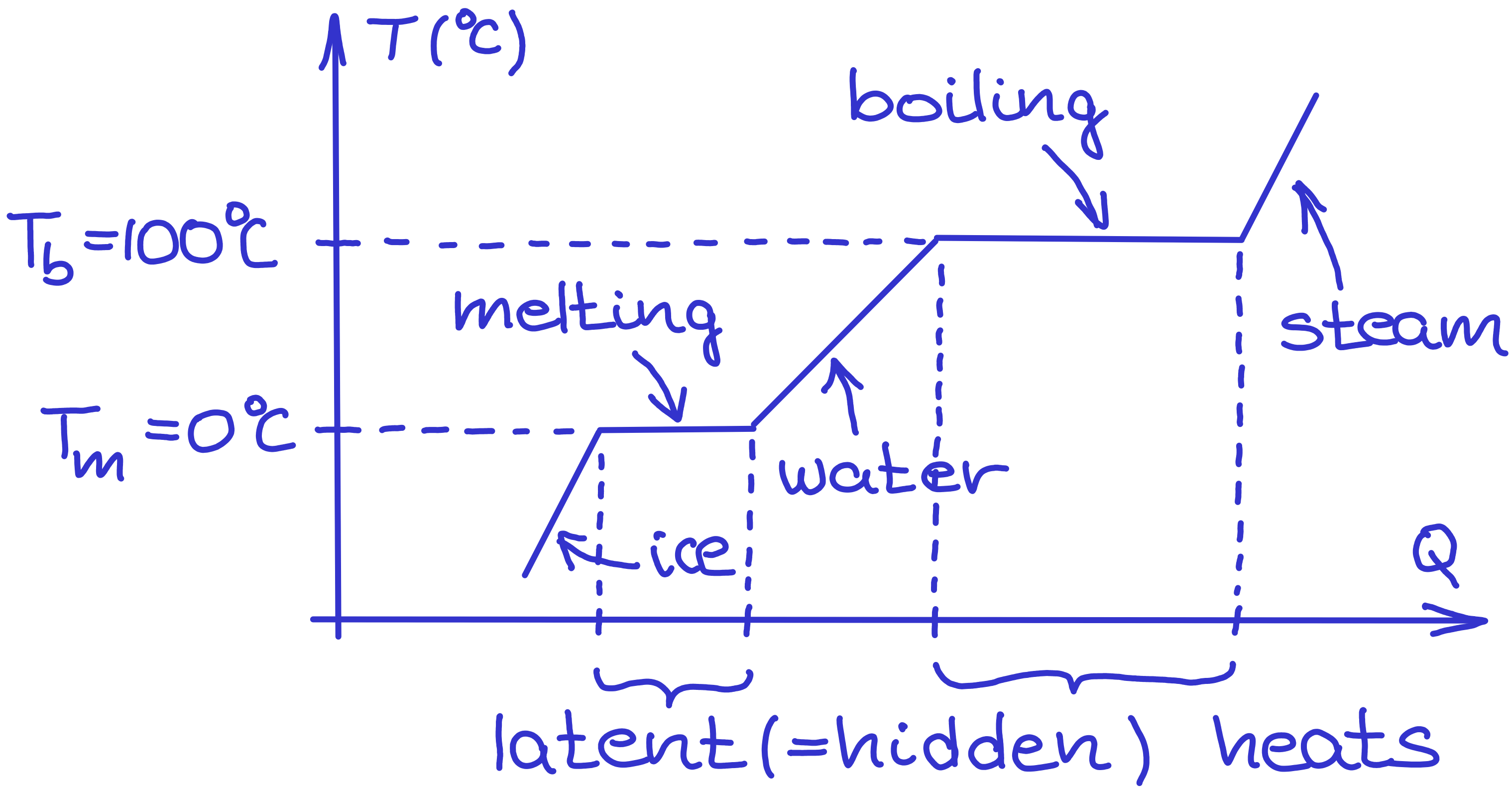
Heat(s) of transformation(s)



melting, solidification } solid-liquid phase transition

$Q = L_F \cdot m$; $L_F = \dfrac{Q}{m}$ $[L_F] = \dfrac{J}{kg}$

↳ heat of fusion

boiling, condensation } liquid-gas phase transition

$Q = L_v \cdot m$; $L_v = \dfrac{Q}{m}$; $[L_v] = \dfrac{J}{kg}$

↳ heat of vaporization

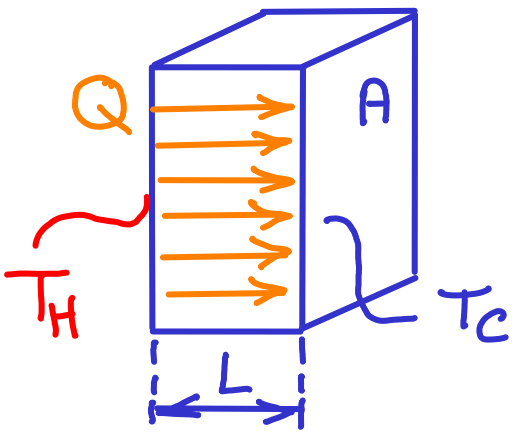
H_2O : $L_F = 333 \dfrac{kJ}{kg}$; $L_v = 2256 \dfrac{kJ}{kg}$

(79.7 cal/g) (540 cal/g)

The three heat transfer mechanisms

conduction, convection, radiation

Conduction:



$Q \propto t$, time

$Q \propto \Delta T = (T_H - T_C)$

$Q \propto A$

$Q \propto \frac{1}{L}$

$$Q = k \cdot \frac{A}{L} \cdot \Delta T \cdot t$$

$$P = \frac{Q}{t} = k \frac{A}{L} \cdot \Delta T$$

k : thermal conductivity

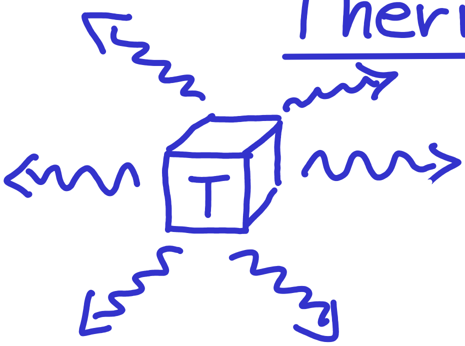
Examples for k in $\frac{W}{m \cdot K} = \frac{W \cdot m}{m^2 \cdot K}$

Silver	: 428
Copper	: 401
Steel	: 14
Glass	: 1-2
Air	: 0.026

Convection: fluid dynamics plus thermodynamics (way too complex)

"Hot air rises."

Thermal radiation



radio- and microwave, mostly infrared, can be visible or ultraviolet

Stefan-Boltzmann law : $P = \sigma \varepsilon A T^4$

T : absolute temperature in kelvin

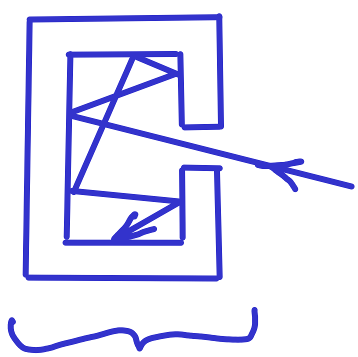
A : surface area of the object

ε or e : emissivity $0 \leq \varepsilon \leq 1$

σ : Stefan-Boltzmann constant:

$$5.6703 \cdot 10^{-8} \frac{W}{m^2 K^4}$$

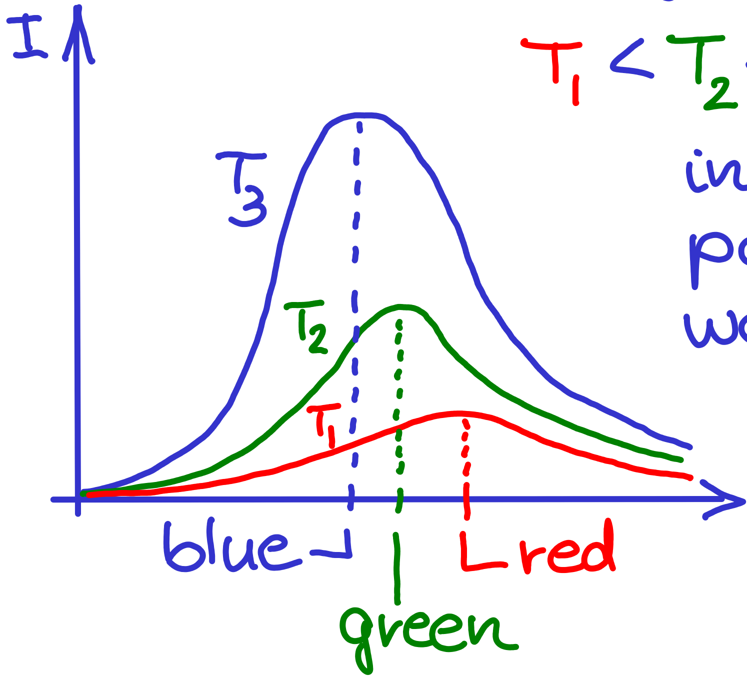
<u>Black-body</u> : a=1 absorbs everything
e=1 emits the most



heated cavity (= oven)

The hole on the cavity behaves like a black-body: it absorbs all the radiation landing on it.

Blackbody radiation



$I = I(\lambda, T)$: intensity distribution: power per area per wavelength

$[I] = \frac{W}{m^2} \cdot \frac{1}{m}$

Wien's displacement law (1911 Nobel)

$$\lambda_{max} \cdot T = b \; ; \quad b = 2.898 \cdot 10^{-3} \; m \cdot K$$

Sun: $\lambda_{max} = 550\,nm \Rightarrow T = 5800\,K$

Stefan-Boltzmann law:

$$P = \sigma \varepsilon A T^4 \; ; \quad \sigma = 5.6705 \cdot 10^{-8} \frac{W}{m^2 K^4}$$

P: total area under the intensity distribution curve.

Max Planck (1918 Nobel): the exact shape of the intensity distribution curve. (You will learn about it in Quantum Mechanics.)