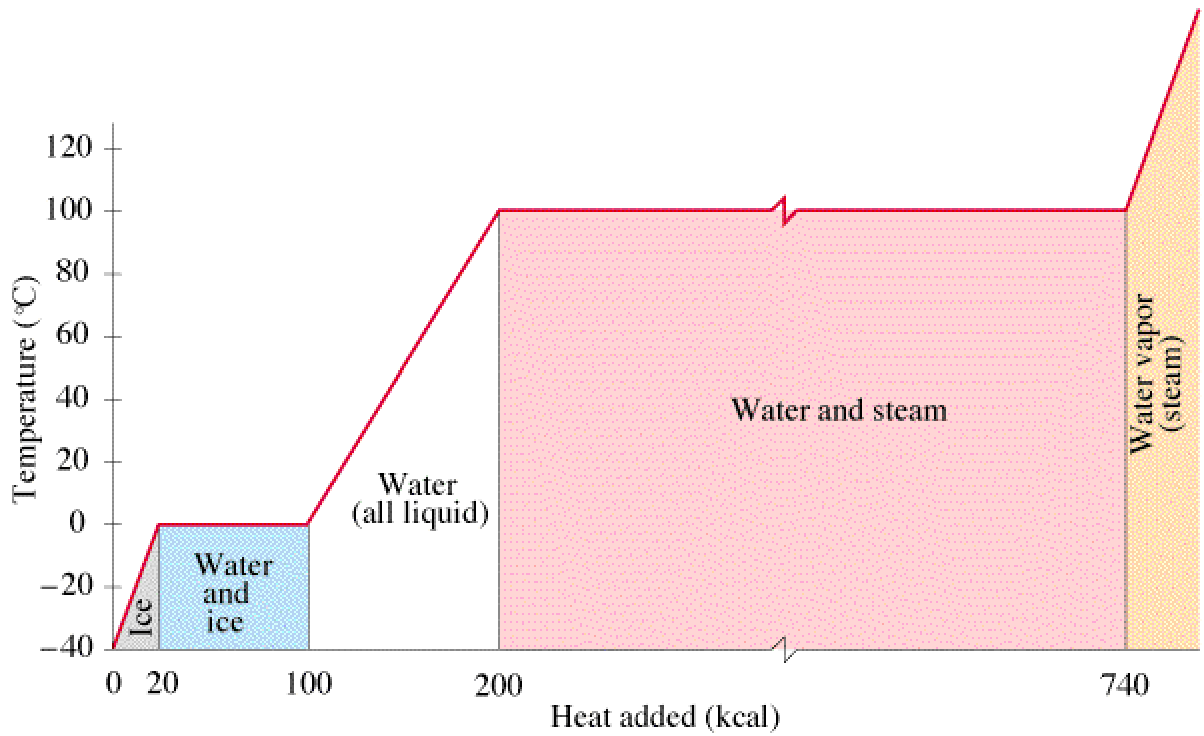
17-6. Phase Change: Latent Heat



Phase change: $\mathit{Solid} \xrightarrow{\mathit{Fusion}} \mathit{Liquid} \xrightarrow{\mathit{Vaporization}} \mathit{Gas}$

Temperature: no change

Latent Heats

$$\text{Solid} \underset{\textit{Releases}}{\overset{\textit{Absorbs}}{\rightleftarrows}} \text{Liquid}$$

heat of fusion L_F

$$\text{Liquid} \underset{\textit{Releases}}{\overset{\textit{Absorbs}}{\rightleftarrows}} \text{Gas}$$

heat of vaporization L_V

Latent heat $Q=mL$ *L -kcal/kg or J/kg*

TABLE 15–4

HEATS OF FUSION AND VAPORIZATION

SUBSTANCE	NORMAL MELTING POINT K	NORMAL MELTING POINT °C	HEAT OF FUSION, L_f (J/kg)	NORMAL BOILING POINT K	NORMAL BOILING POINT °C	HEAT OF VAPORIZATION, L_v (J/kg)
Helium	*	*	*	4.216	−268.93	20.9×10^3
Hydrogen	13.84	−259.31	58.6×10^3	20.26	−252.89	452×10^3
Nitrogen	63.18	−209.97	25.5×10^3	77.34	−195.8	201×10^3
Oxygen	54.36	−218.79	13.8×10^3	90.18	−183.0	213×10^3
Ethanol	159	−114	104.2×10^3	351	78	854×10^3
Mercury	234	−39	11.8×10^3	630	357	272×10^3
Water	273.15	0.00	334×10^3	373.15	100.00	2256×10^3
Sulfur	392	119	38.1×10^3	717.75	444.60	326×10^3
Lead	600.5	327.3	24.5×10^3	2023	1750	871×10^3
Antimony	903.65	630.50	165×10^3	1713	1440	561×10^3
Silver	1233.95	960.80	88.3×10^3	2466	2193	2336×10^3
Gold	1336.15	1063.00	64.5×10^3	2933	2660	1578×10^3
Copper	1356	1083	134×10^3	1460	1187	5069×10^3

*A pressure in excess of 25 atmospheres is required to make helium solidify. At 1 atmosphere pressure, helium remains a liquid down to absolute zero.

17-7. Mechanisms of Heat Transfer

On a cold day, why is a piece of metal feels much colder to the touch than a piece of wood?

Heat transfer: only when there is a temperature difference

Conduction: need medium

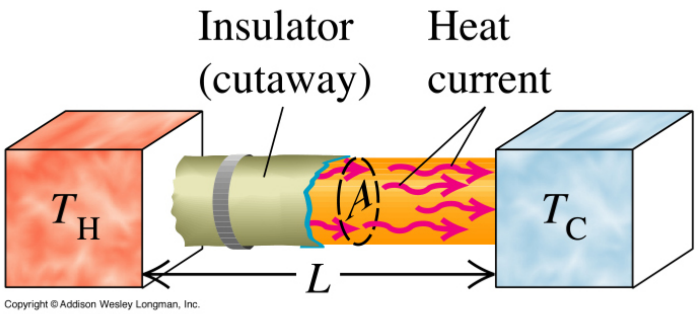
Convection: need medium

Radiation: No medium

Heat may be transferred by more than one way at the same time

Conduction

Molecular collision



$$H = \frac{dQ}{dt} = kA\frac{T_H - T_C}{L}$$

k: thermal conductivity

$$J/s \cdot m \cdot K = W/m \cdot K$$

Or:

$$H = \frac{dQ}{dt} = A\frac{T_H - T_C}{R}$$

$R=L/k$: thermal resistance

Conductors:

Silver	406
Copper	385
Aluminum	205
Steel	50

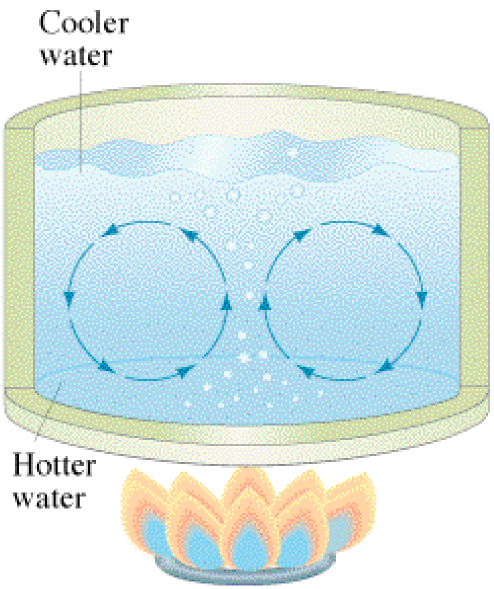
Insulators:

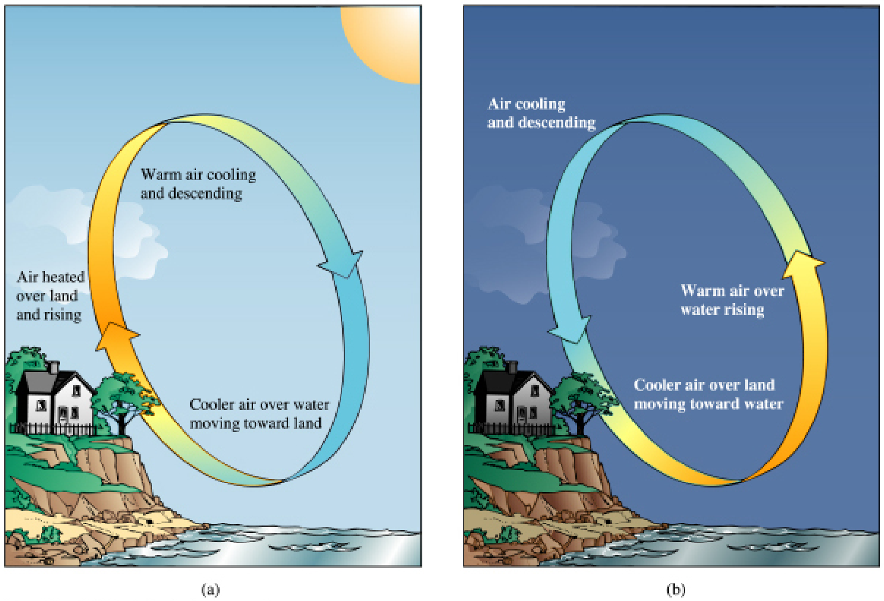
Fiberglass	0.04
Wool	0.04
Goose down	0.025
Air	0.024

Convection

Mass movements of molecules from one place to another.
Only in fluids: liquids & gases.

Forced convection:	circulation by pump/blower
Natural convection:	natural density differences





Radiation

Every body emits energy in the form of electromagnetic radiation, no need for a medium.

Stefan-Boltzmann Equation

$$H = \frac{dQ}{dt} = Ae\sigma T^4$$

Stefan-Boltzmann constant $\sigma = 5.67 \times 10^{-8}$ W/m^2-K^4

Emissivity *e*: 0 (shiny surfaces) ~ 1(black)

Net flow rate of heat radiation $$\frac{dQ}{dt} = Ae\sigma(T_1^4 - T_2^4)$$

A good absorber is also a good emitter