Hitastig og varmi

Núllta lögmál varmafræðinnar

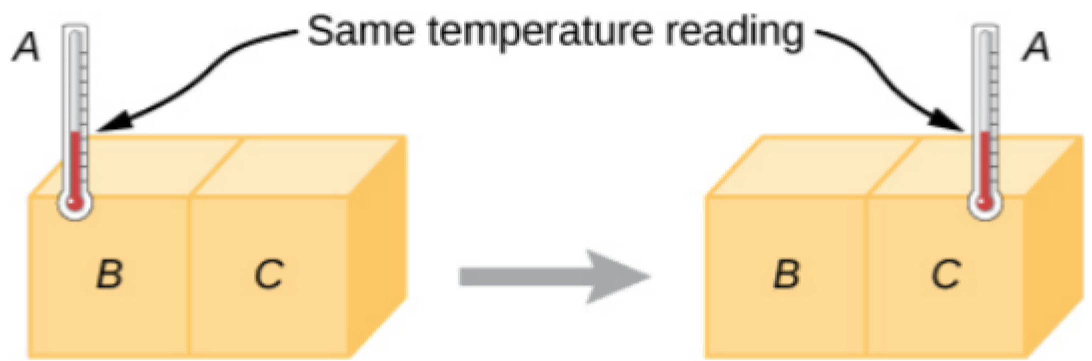

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Figure 1.2 If thermometer *A* is in thermal equilibrium with object *B*, and *B* is in thermal equilibrium with *C*, then *A* is in thermal equilibrium with *C*. Therefore, the reading on *A* stays the same when *A* is moved over to make contact with *C*.

Tveir hlutir í varmafræðilegu jafnvægi (jafn mikill varmi flýtur í hvora átt milli þeirra) eru með sama hitastig

Við munum síðar tengja hitastig við innri orku hluta og seinna sjá merkileg tengsl þess við óreiðu

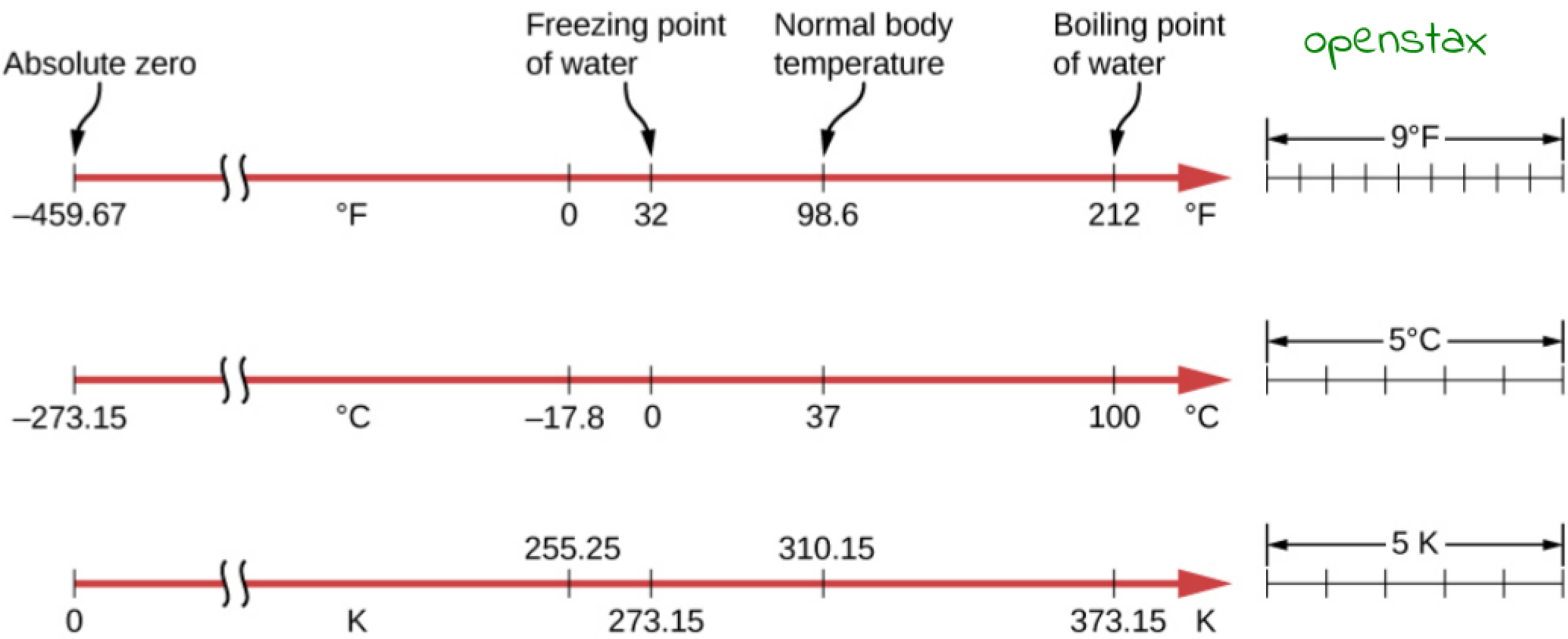

Figure 1.4 Relationships between the Fahrenheit, Celsius, and Kelvin temperature scales are shown. The relative sizes of the scales are also shown.

Munum sjá að Kelvin-kvarðinn fellur mjög vel að sígildri lýsingu á kjörgasi

Hitapensla - thermal expansion

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Linear Thermal Expansion

According to experiments, the dependence of thermal expansion on temperature, substance, and original initial length is summarized in the equation

$$\frac{dL}{dT} = \alpha L \qquad (1.1)$$

where $\frac{dL}{dT}$ is the instantaneous change in length per temperature, L is the length, and α is the **coefficient of linear expansion**, a material property that varies slightly with temperature. As α is nearly constant and also very small, for practical purposes, we use the linear approximation:

$$\Delta L = \alpha L \Delta T \qquad (1.2)$$

where ΔL is the change in length and ΔT is the change in temperature.

Línulega nálgunin getur góð fyrir smá bil í hitastigi, í raun getur α verið flókið fall af T....

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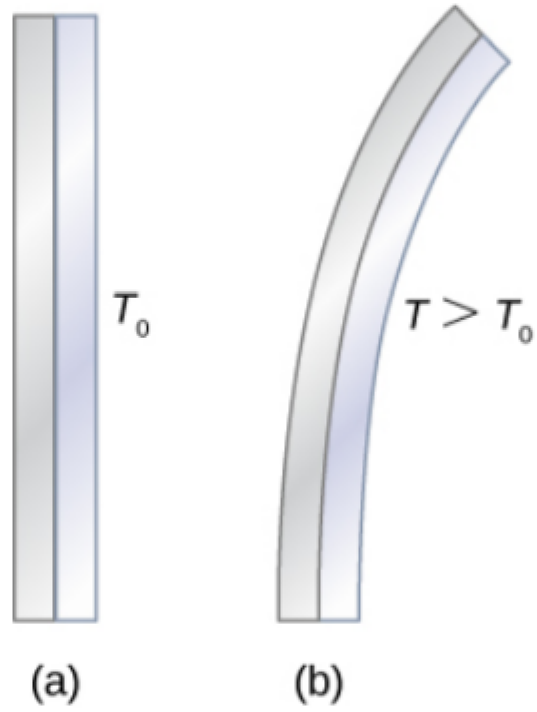
Material	Coefficient of Linear Expansion α (1/°C)	Coefficient of Volume Expansion β (1/°C)
Solids		
Aluminum	25×10^{-6}	75×10^{-6}
Brass	19×10^{-6}	56×10^{-6}
Copper	17×10^{-6}	51×10^{-6}
Gold	14×10^{-6}	42×10^{-6}
Iron or steel	12×10^{-6}	35×10^{-6}
Invar (nickel-iron alloy)	0.9×10^{-6}	2.7×10^{-6}
Lead	29×10^{-6}	87×10^{-6}
Silver	18×10^{-6}	54×10^{-6}
Glass (ordinary)	9×10^{-6}	27×10^{-6}
Glass (Pyrex®)	3×10^{-6}	9×10^{-6}
Quartz	0.4×10^{-6}	1×10^{-6}
Concrete, brick	$\sim 12 \times 10^{-6}$	$\sim 36 \times 10^{-6}$
Marble (average)	2.5×10^{-6}	7.5×10^{-6}
Liquids		
Ether		1650×10^{-6}
Ethyl alcohol		1100×10^{-6}
Gasoline		950×10^{-6}
Glycerin		500×10^{-6}
Mercury		180×10^{-6}
Water		210×10^{-6}
Air and most other gases at atmospheric pressure		3400×10^{-6}



Mismunapensla

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5

Thermal Expansion in Two Dimensions

For small temperature changes, the change in area ΔA is given by

$$\Delta A = 2\alpha A \Delta T \tag{1.3}$$

where ΔA is the change in area A, ΔT is the change in temperature, and α is the coefficient of linear expansion, which varies slightly with temperature. (The derivation of this equation is analogous to that of the more important equation for three dimensions, below.)

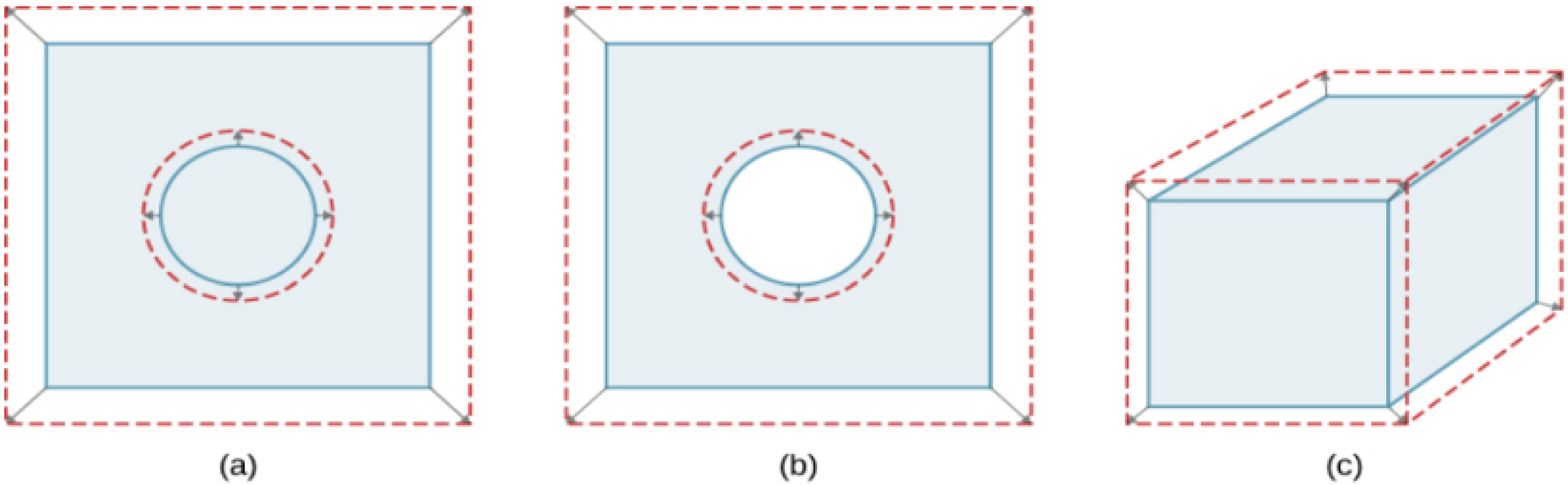

Figure 1.7 In general, objects expand in all directions as temperature increases. In these drawings, the original boundaries of the objects are shown with solid lines, and the expanded boundaries with dashed lines. (a) Area increases because both length and width increase. The area of a circular plug also increases. (b) If the plug is removed, the hole it leaves becomes larger with increasing temperature, just as if the expanding plug were still in place. (c) Volume also increases, because all three dimensions increase.

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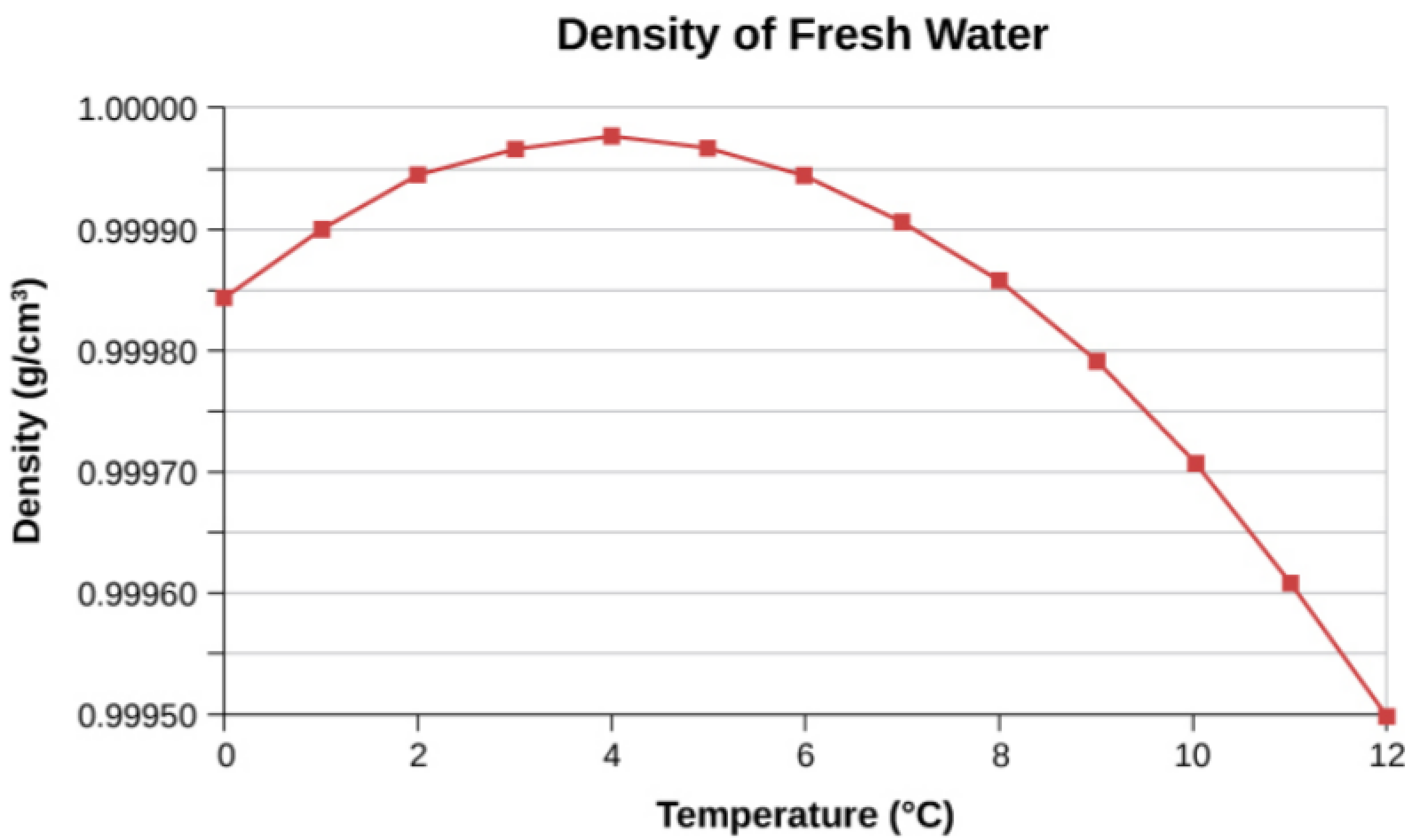
Thermal Expansion in Three Dimensions

The relationship between volume and temperature $\frac{dV}{dT}$ is given by $\frac{dV}{dT} = \beta V$, where β is the **coefficient of volume expansion**. As you can show in Exercise 1.60, $\beta = 3\alpha$. This equation is usually written as

$$\Delta V = \beta V \Delta T. \tag{1.4}$$

Note that the values of β in Table 1.2 are equal to 3α except for rounding.

Dæmi um flóknari hegðun



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Skiptir miklu máli fyrir lífkerfi og önnur ....

Varmaflutningur, eðlisvarmi og varmamælingar

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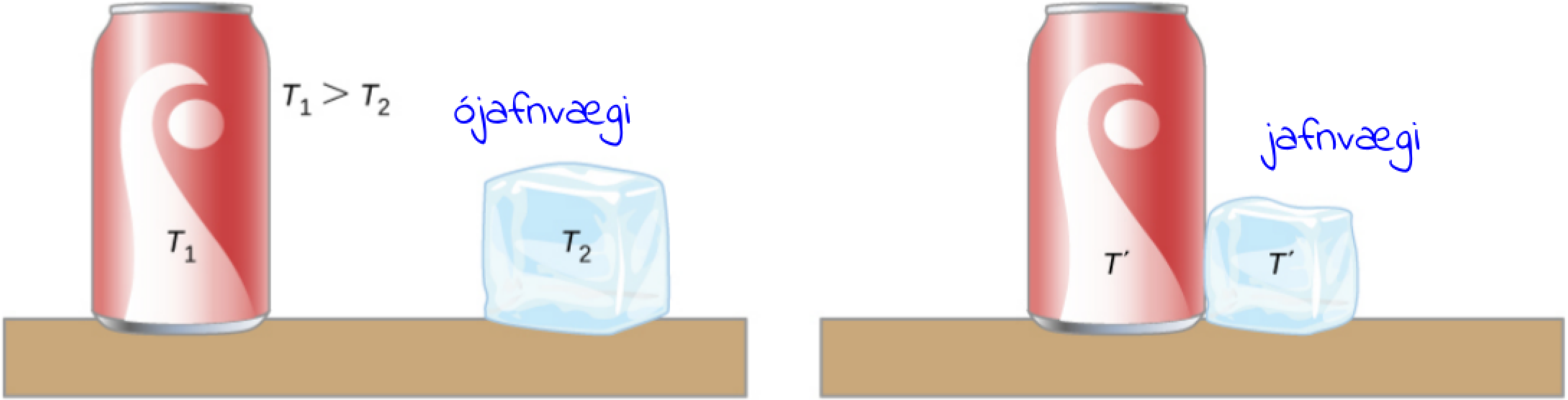
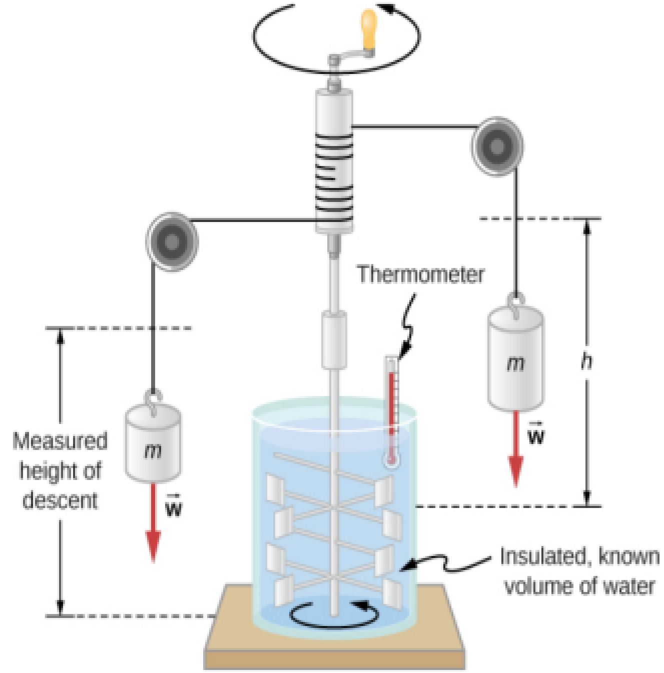


(b)

Varmaflutningur --> breyting á innri orku



Jafngildi vélrænnar og varmaorku

$$1{,}000 \text{ kcal} = 4186 \text{ J}$$

Figure 1.10 Joule's experiment established the equivalence of heat and work. As the masses descended, they caused the paddles to do work, $W = mgh$, on the water. The result was a temperature increase, ΔT, measured by the thermometer. Joule found that ΔT was

Varmarýmd - eðlisvarmi

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Heat Transfer and Temperature Change

A practical approximation for the relationship between heat transfer and temperature change is:

$$Q = mc\Delta T, \qquad \textbf{1.5}$$

where Q is the symbol for heat transfer ("quantity of heat"), m is the mass of the substance, and ΔT is the change in temperature. The symbol c stands for the **specific heat** (also called "*specific heat capacity*") and depends on the material and phase. The specific heat is numerically equal to the amount of heat necessary to change the temperature of 1.00 kg of mass by 1.00 °C. The SI unit for specific heat is J/(kg × K) or J/(kg × °C). (Recall that the temperature change ΔT is the same in units of kelvin and degrees Celsius.)

Eðlisvarmarýmd $c = \frac{C}{m}$ þar sem C er varmarýmd hlutar með massa m

Í raun getur c verið flókið fall af hitastigi T: $c = c(T)$

(9)

Substances	Specific Heat (c)	
Solids	J/kg · °C	kcal/kg · °C[2]
Aluminum	900	0.215
Asbestos	800	0.19
Concrete, granite (average)	840	0.20
Copper	387	0.0924
Glass	840	0.20
Gold	129	0.0308
Human body (average at 37 °C)	3500	0.83
Ice (average, −50 °C to 0 °C)	2090	0.50
Iron, steel	452	0.108
Lead	128	0.0305
Silver	235	0.0562
Wood	1700	0.40
Liquids		
Benzene	1740	0.415
Ethanol	2450	0.586
Glycerin	2410	0.576
Mercury	139	0.0333
Water (15.0 °C)	4186	1.000
Gases[3]		
Air (dry)	721 (1015)	0.172 (0.242)
Ammonia	1670 (2190)	0.399 (0.523)
Carbon dioxide	638 (833)	0.152 (0.199)
Nitrogen	739 (1040)	0.177 (0.248)
Oxygen	651 (913)	0.156 (0.218)
Steam (100 °C)	1520 (2020)	0.363 (0.482)

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$$c(T) = \frac{1}{m}\frac{dQ}{dT}$$

$$Q(T_2 - T_1) = m\int_{T_1}^{T_2} c(T)\,dT$$

því eru nákvæmar mælingar á c(T) mjög mikilvægar. þær gefa upplýsingar um innri orku efna, fasabreytingar ....

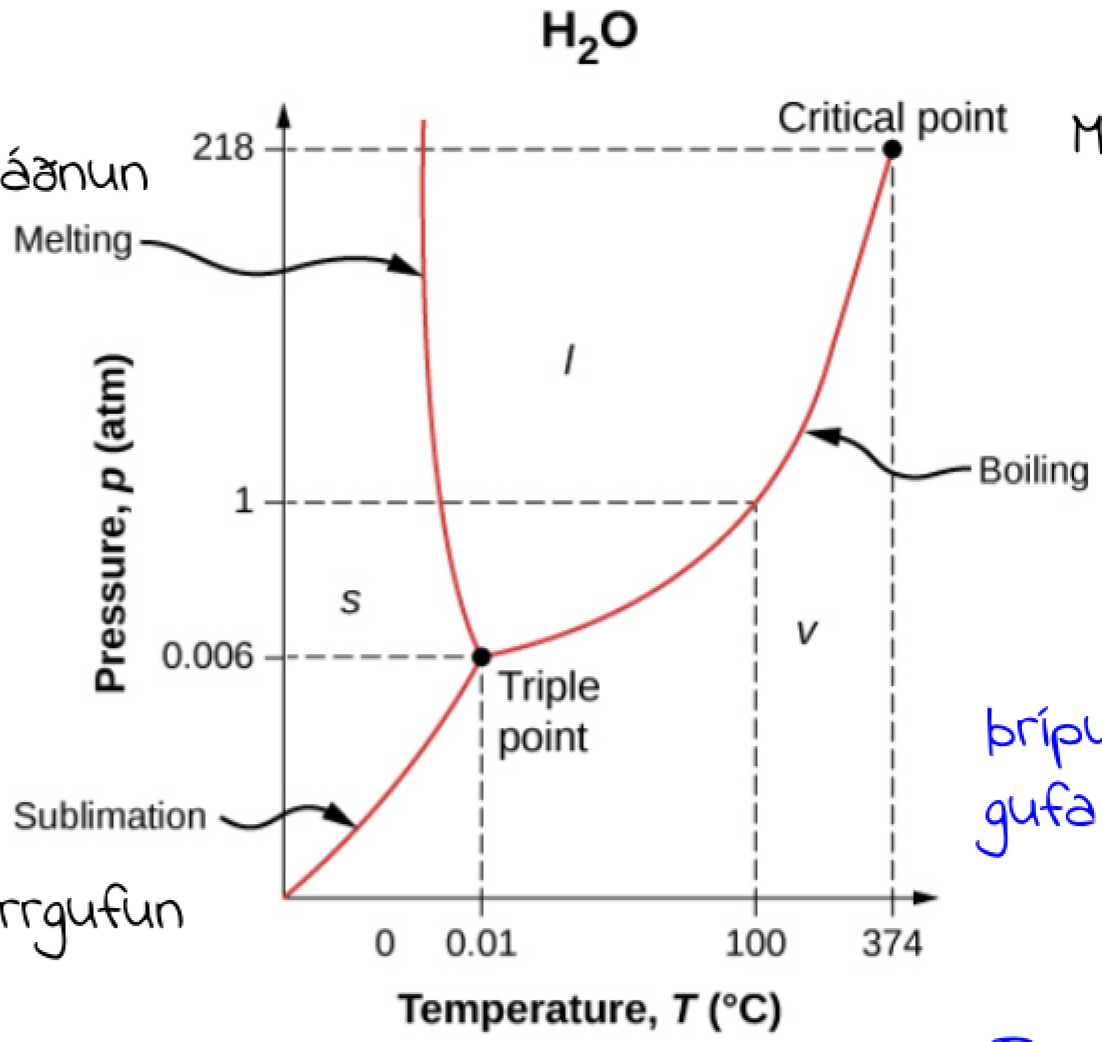
Fasabreytingar

l: vökvi

s: fast efni

v: gufa - gas

Bráðnun



Markpunktur

Suða

Þurrgufun

þrípunktur, eini pT-punkturinn sem vökvi, gufa og ís geta verið í jafnvægi við

Fasaritið er mun flóknara þegar bætt er við öðrum kristallagerðum íss

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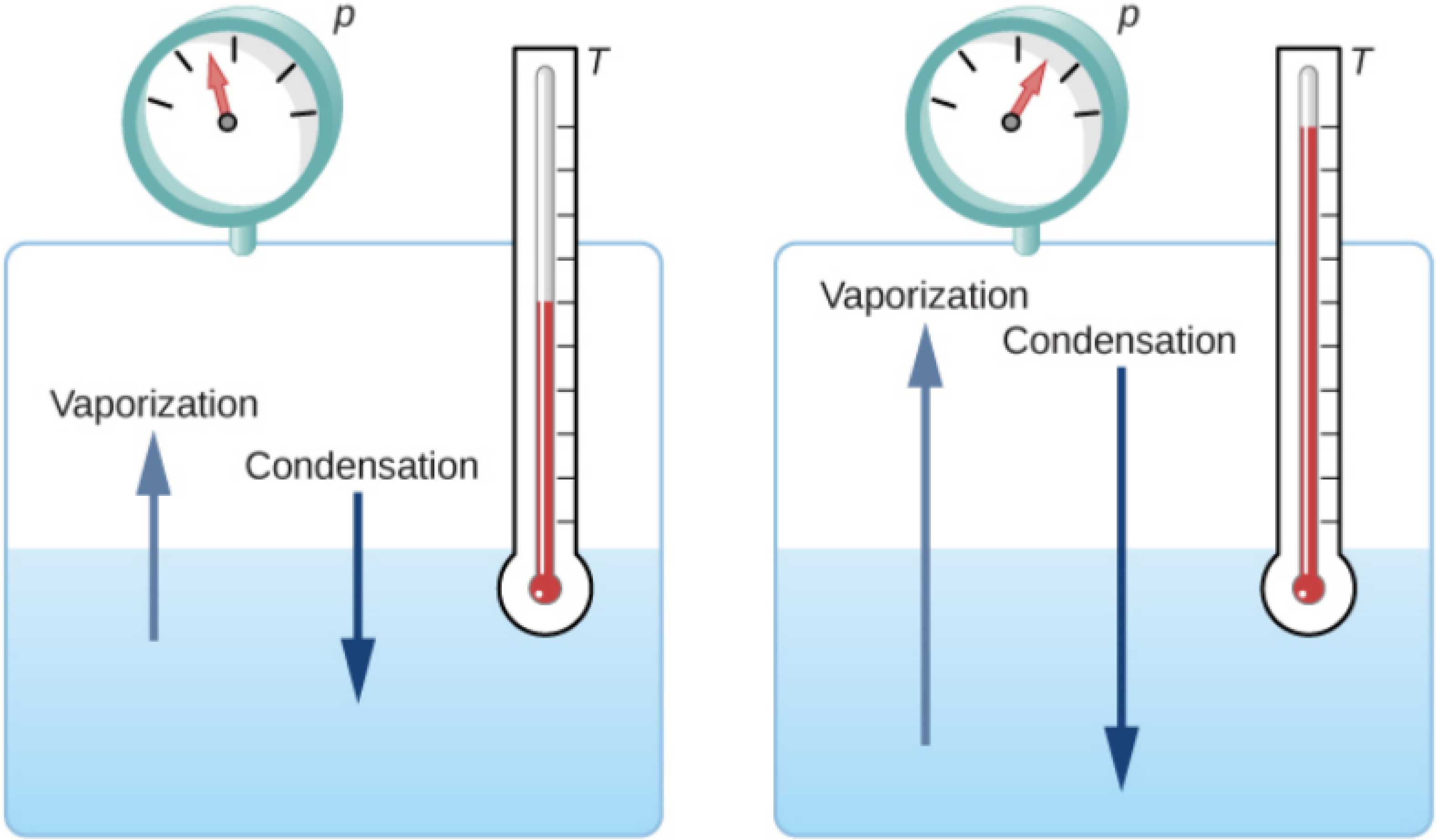

(a) (b)

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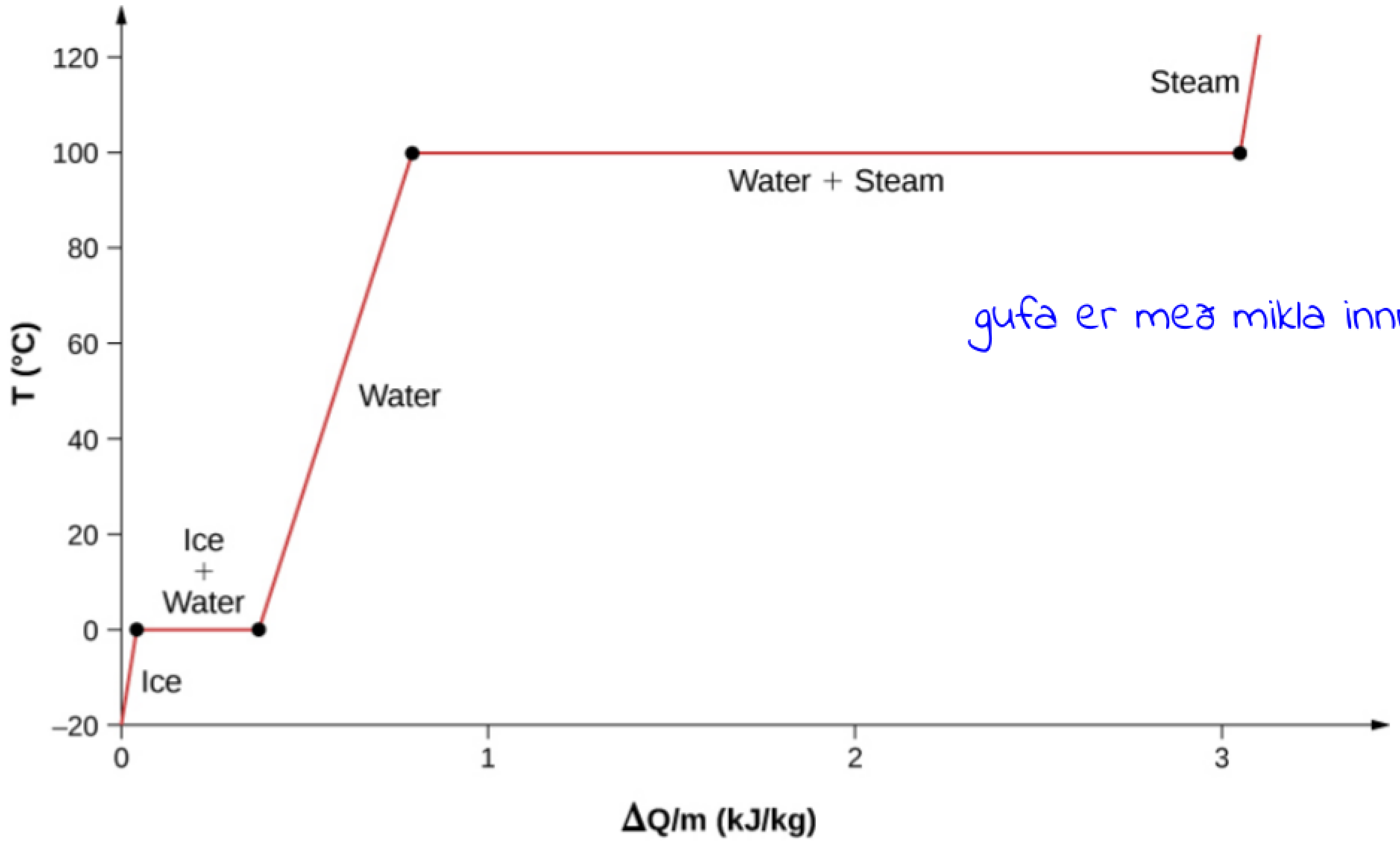
Lokað kerfi í jafnvægi. Við hærra hitastig er meira flæði sameinda úr og í fasana. Jafnvægi þýðir að flæðið verður að vera jafnt í báðar áttir

Fasabreytngar - hamskiptavarmi, Phase changes - latent heat



gufa er með mikla innri orku

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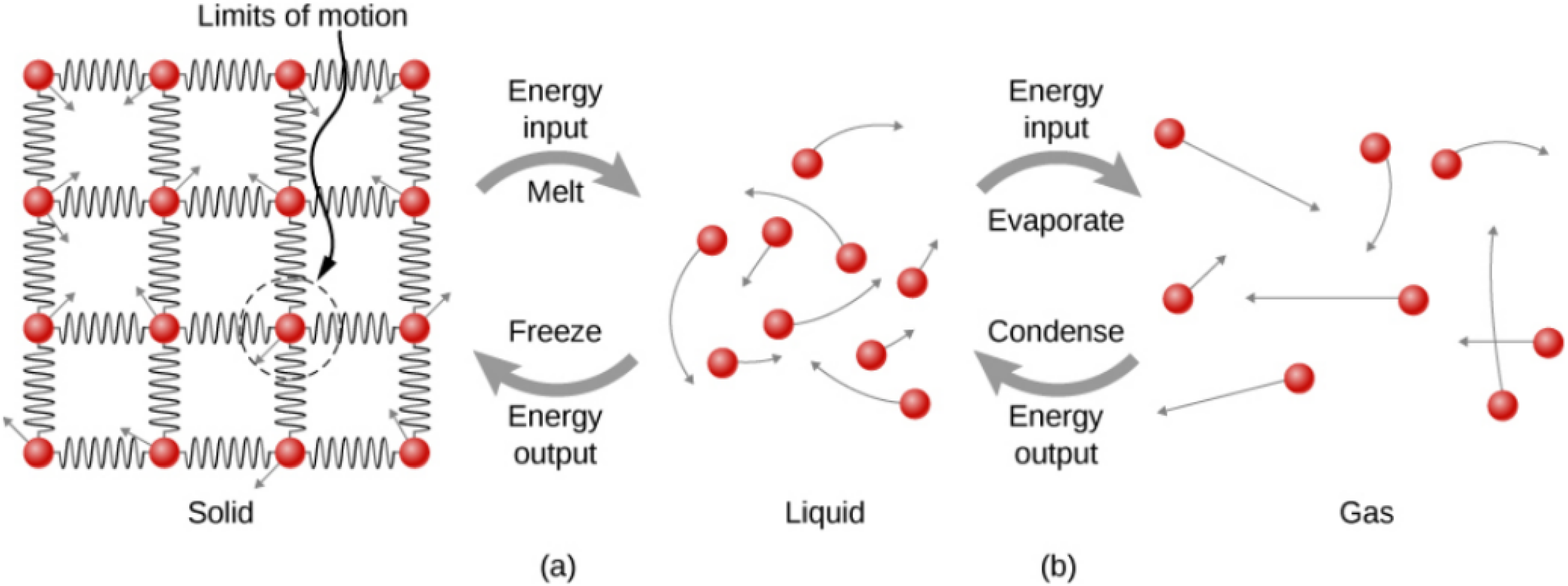

$$Q = mL_f$$ bráðnun/frysting

$$Q = mL_v$$ suða/þétting

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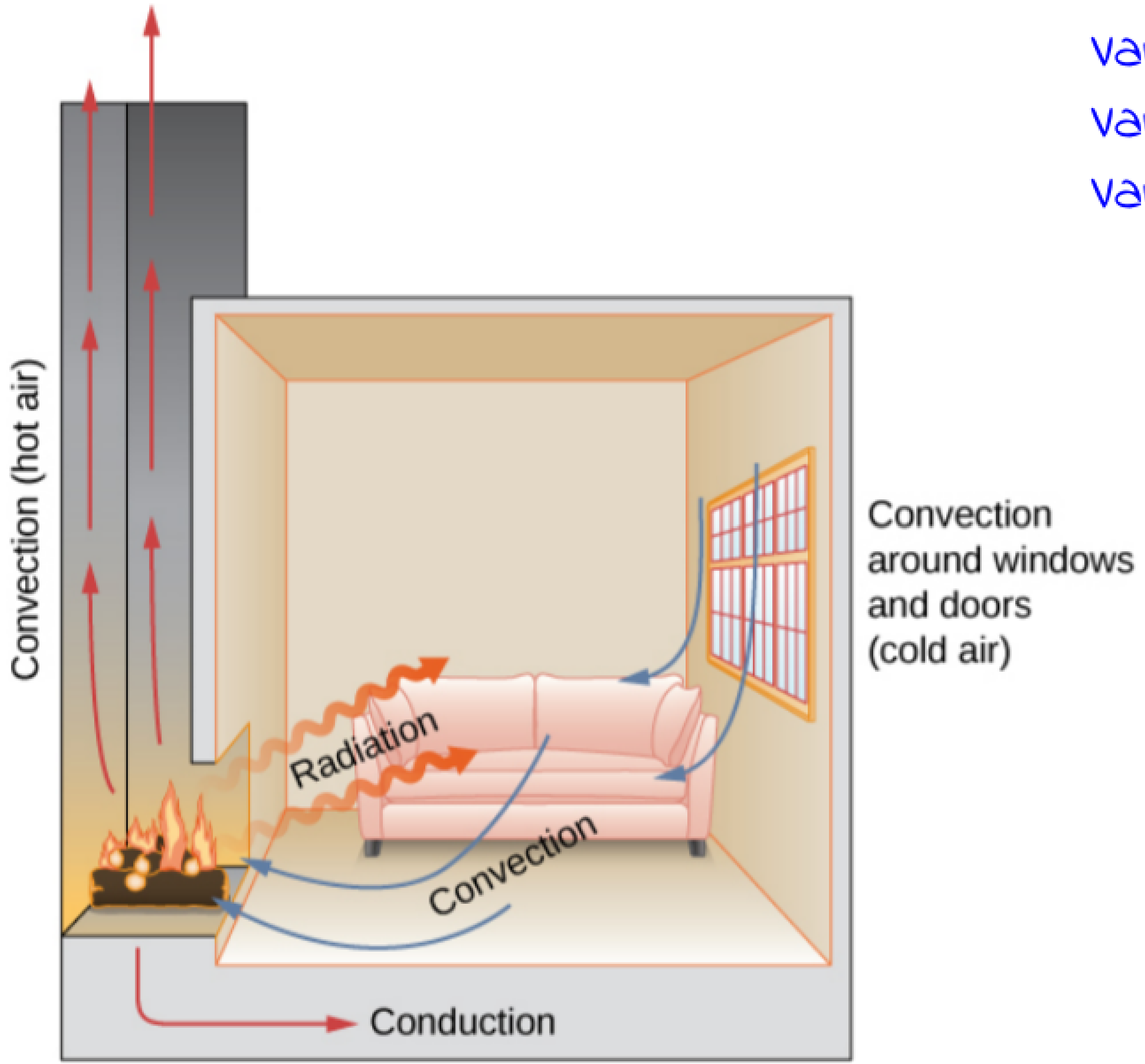
		L_f			L_v	
Substance	**Melting Point** (°C)	**kJ/kg**	**kcal/kg**	**Boiling Point** (°C)	**kJ/kg**	**kcal/kg**
Helium[2]	–272.2 (0.95 K)	5.23	1.25	–268.9 (4.2 K)	20.9	4.99
Hydrogen	–259.3 (13.9 K)	58.6	14.0	–252.9 (20.2 K)	452	108
Nitrogen	–210.0 (63.2 K)	25.5	6.09	–195.8 (77.4 K)	201	48.0
Oxygen	–218.8 (54.4 K)	13.8	3.30	–183.0 (90.2 K)	213	50.9
Ethanol	–114	104	24.9	78.3	854	204
Ammonia	–75	332	79.3	–33.4	1370	327
Mercury	–38.9	11.8	2.82	357	272	65.0
Water	0.00	334	79.8	100.0	2256[3]	539[4]
Sulfur	119	38.1	9.10	444.6	326	77.9
Lead	327	24.5	5.85	1750	871	208
Antimony	631	165	39.4	1440	561	134

varmaflutningur

varmaleiðni
varmaburður
varmageislun



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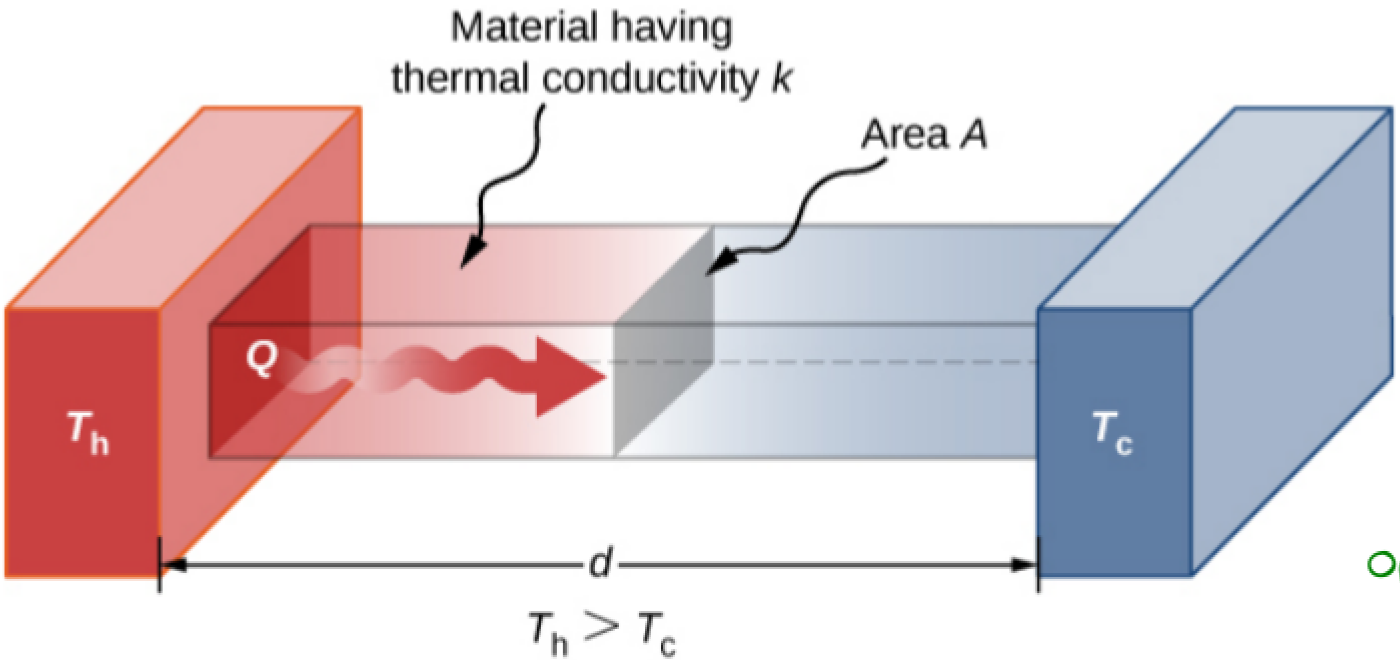
varmaleiani



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$$P = \frac{dQ}{dt} = \frac{kA}{d}\left[T_h - T_c\right]$$

$$P = -kA\frac{dT}{dx}$$

almennar

Substance	Thermal Conductivity *k* (W/m · °C)
Diamond	2000
Silver	420
Copper	390
Gold	318
Aluminum	220
Steel iron	80
Steel (stainless)	14

Geislun

Svarthlutargeislun, e=1

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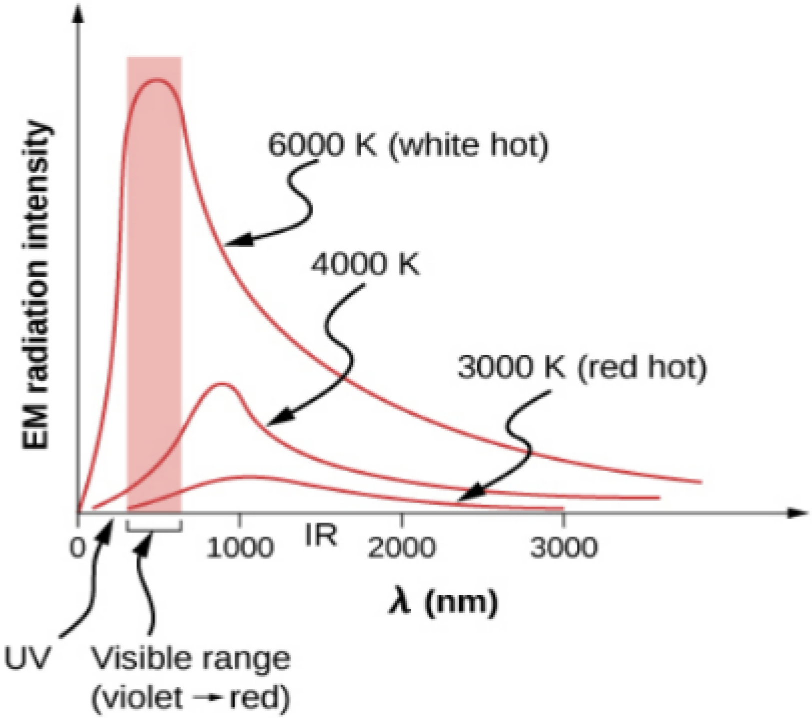
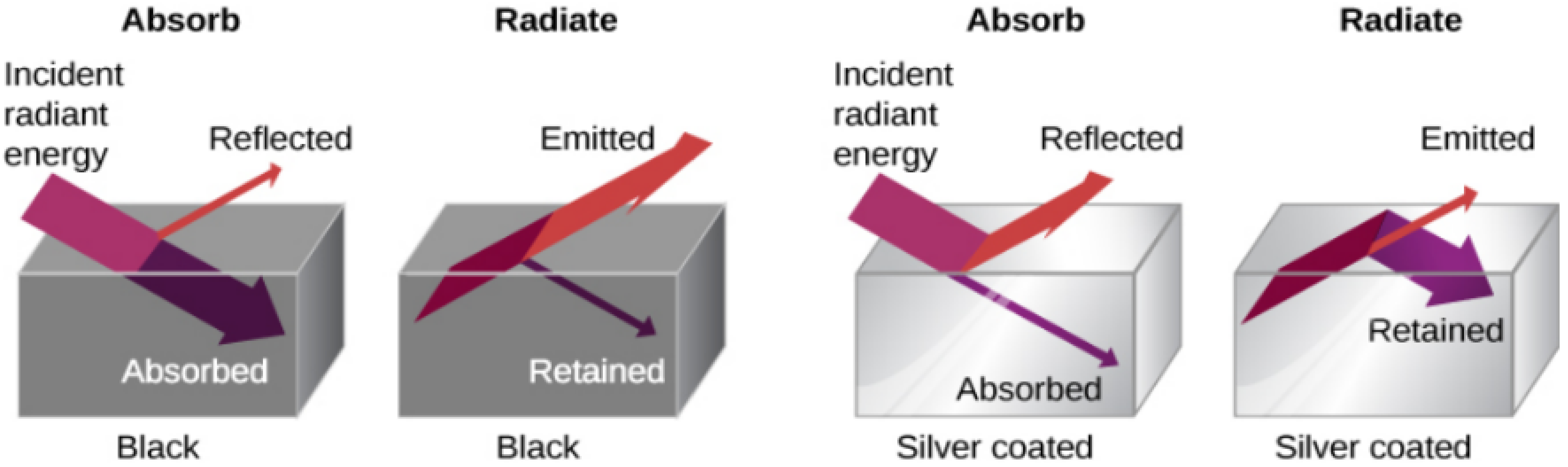
Ásamt varmarýmd
upphaf skammtafræði



(a)

(b)



Lögmál Stefans og Boltzmanns

$$P = \sigma A e T^4$$

A = flötur hlutar

e = eðlisgeislun

$\sigma = 5.67 \times 10^{-8}$ J/s m^2 K^4

$$P_{net} = \sigma e A \left[T_2^4 - T_1^4 \right]$$

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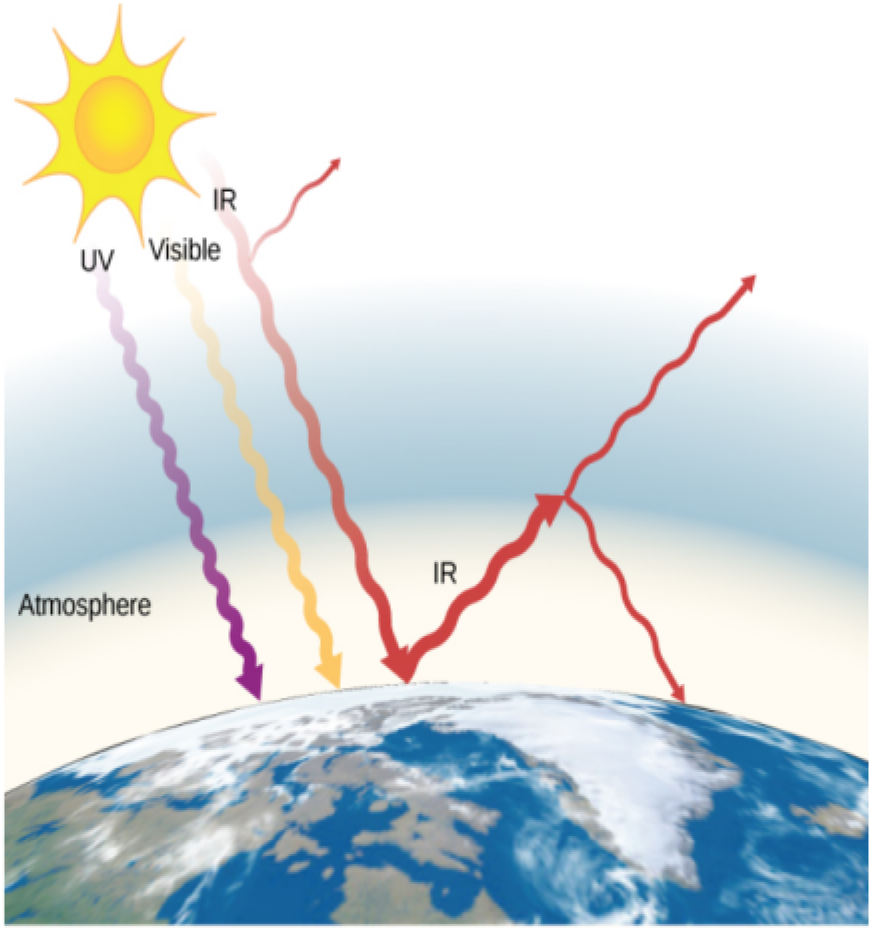

Figure 1.33 The greenhouse effect is the name given to the increase of Earth's temperature due to absorption of radiation in the atmosphere. The atmosphere is transparent to incoming visible radiation and most of the Sun's infrared. The Earth absorbs that energy and re-emits it. Since Earth's temperature is much lower than the Sun's, it re-emits the energy at much longer wavelengths, in the infrared. The atmosphere absorbs much of that infrared radiation and radiates about half of the energy back down, keeping Earth warmer than it would otherwise be. The amount of trapping depends on concentrations of trace gases such as carbon dioxide, and an increase in the concentration of these gases increases Earth's surface temperature.