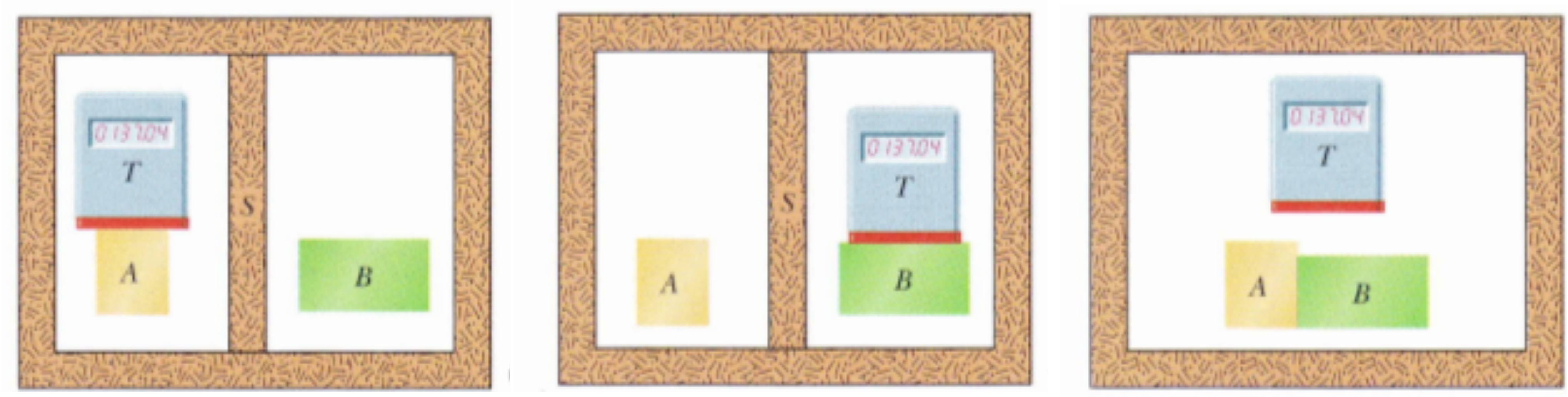
Página web

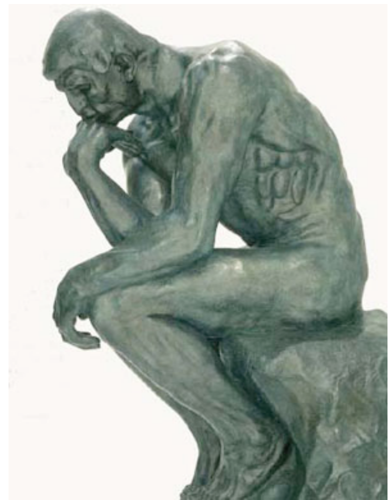
http://wwwprof.uniandes.edu.co/~s.vargas54/Fisica2/

HEMOS VISTO ... Ley cero de la Termodinámica

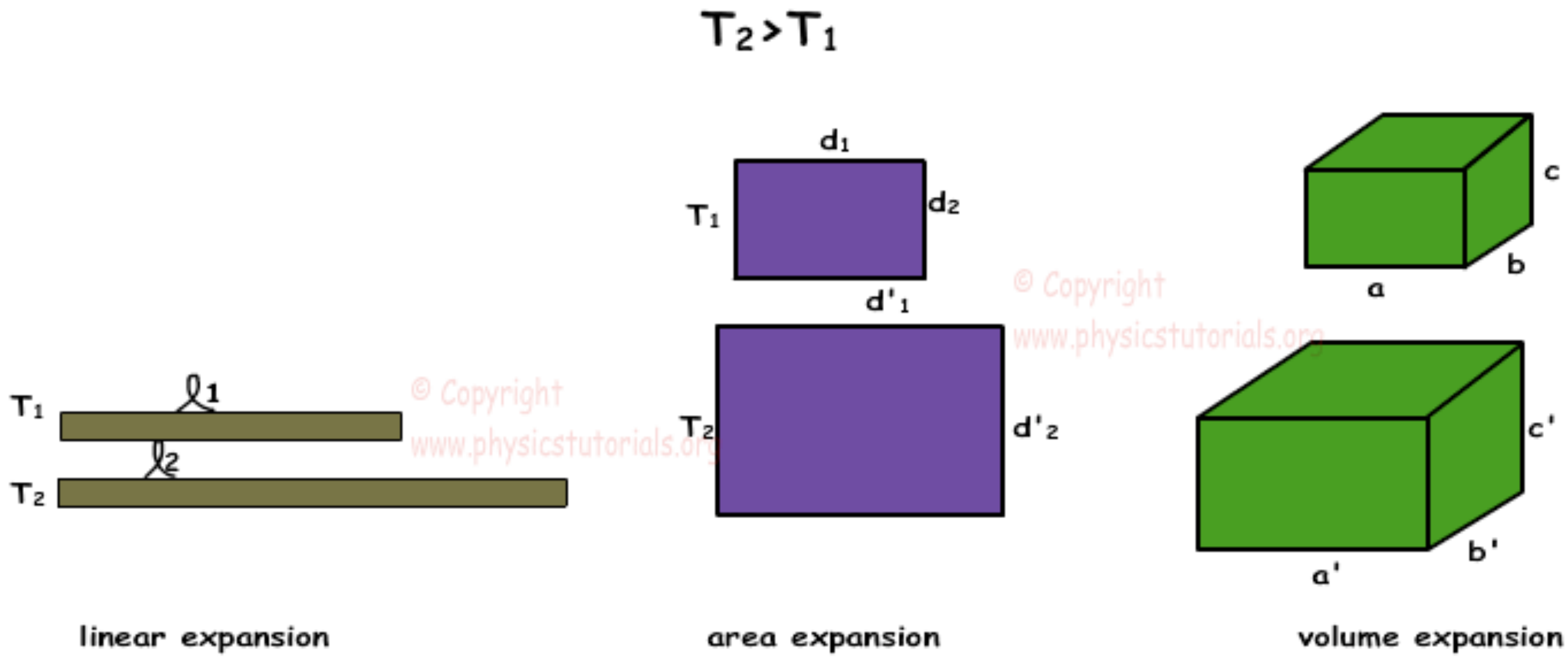


Si los cuerpos A y B están en equilibrio térmico con un tercer cuerpo C, entonces los cuerpos A y B están en equilibrio térmico entre ellos.

Cada cuerpo tiene una propiedad llamada temperatura.



Expansión térmica



$$\Delta L = L\alpha\,\Delta T,$$

Coeficiente de expansión lineal

$$\Delta V = V\beta\,\Delta T,$$

Coeficiente de expansión volumetrica

Clase 3

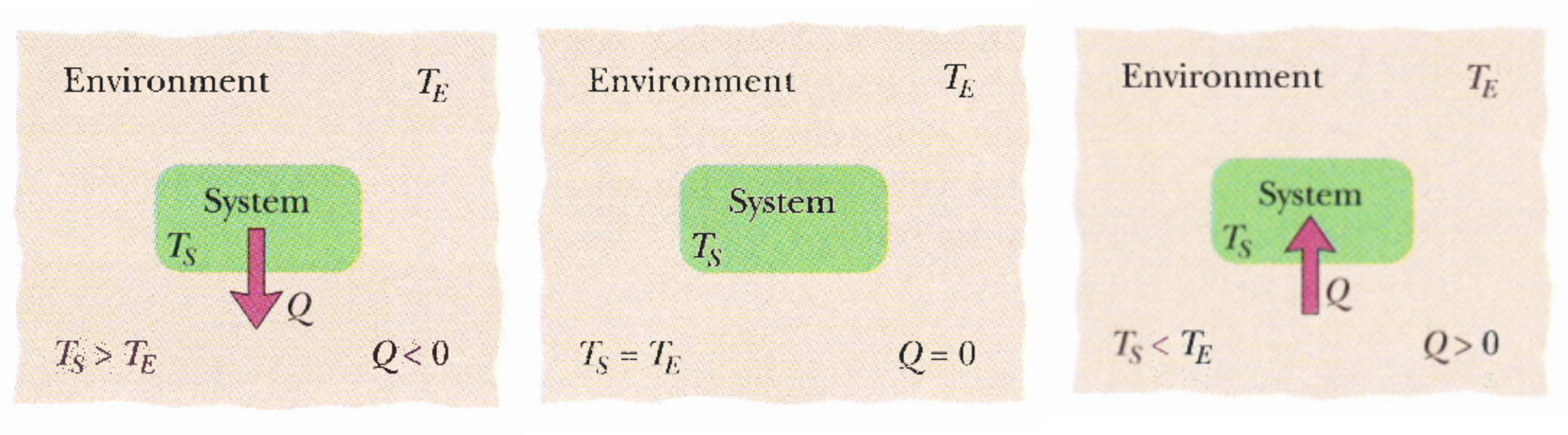
29/01/2013

Lecturas 18-8 a 18-12


Temperatura y Calor

Temperatura y Calor

Equilibrio térmico



Calor es la energía que se transfiere entre un sistema y el medio circundante debido a una diferencia de temperatura existente entre ambos.

Caloria

$$1 \text{ cal} = 3.968 \times 10^{-3} \text{ Btu} = 4.1868 \text{ J.}$$

La cantidad de calor que se necesita para calentar un gramo de agua de 14.5 °C a 15.5 °C

Kcal

Absorción de calor por sólidos y líquidos

Capacidad Calorífica

$$Q = C\,\Delta T = C(T_f - T_i),$$

Calor específico

Capacidad Calorífica por unidad de masa

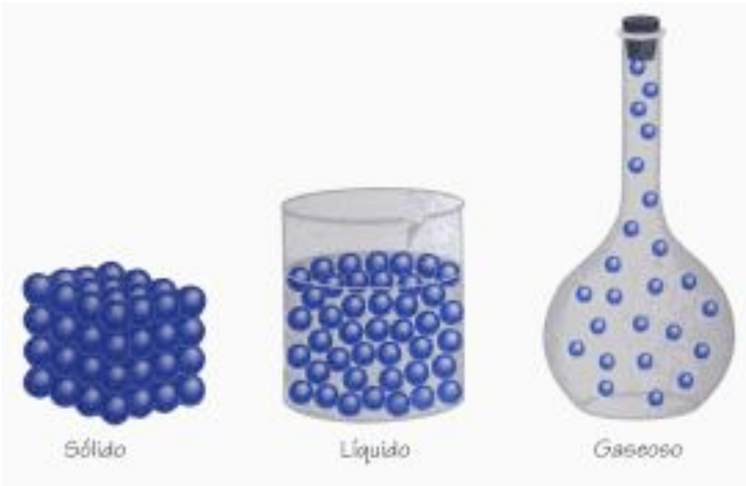
$$Q = cm\,\Delta T = cm(T_f - T_i).$$

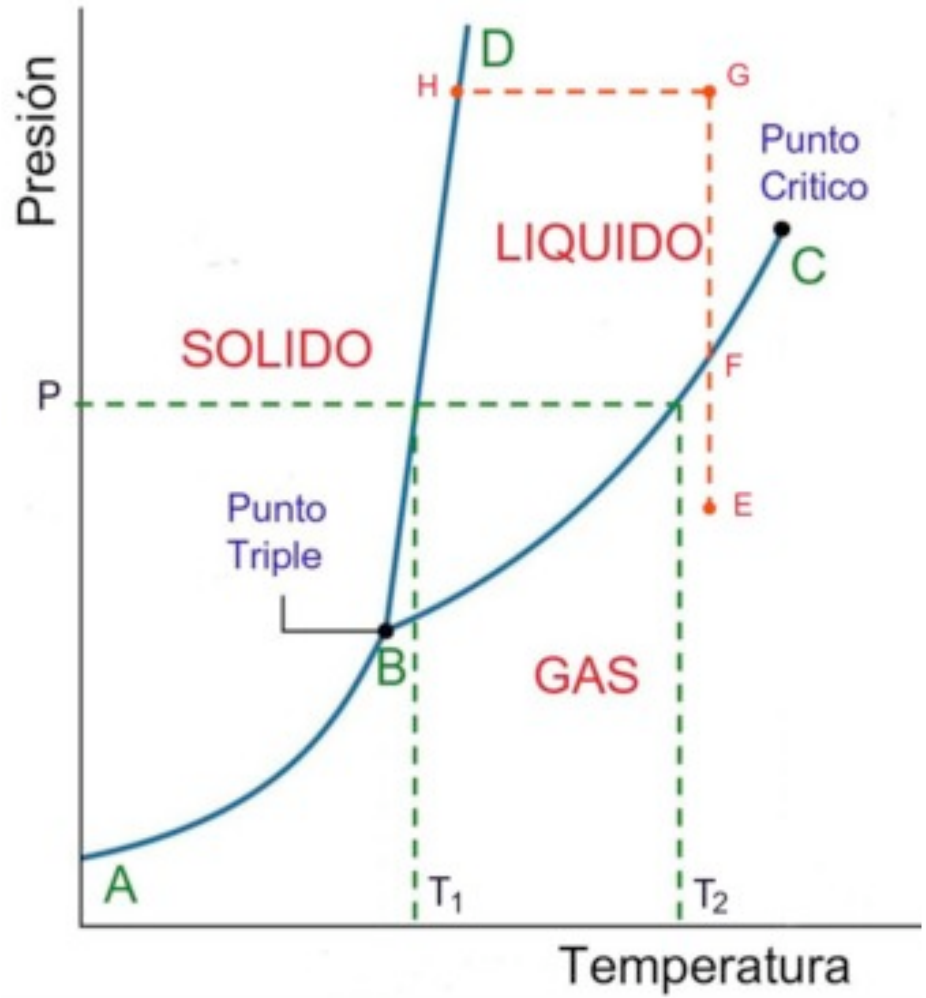
$$c = 1\ \text{cal/g}\cdot\text{C}^\circ = 1\ \text{Btu/lb}\cdot\text{F}^\circ = 4190\ \text{J/kg}\cdot\text{K}.$$

Substance	Specific Heat $\frac{\text{cal}}{\text{g}\cdot\text{K}}$	Specific Heat $\frac{\text{J}}{\text{kg}\cdot\text{K}}$
Elemental Solids		
Lead	0.0305	128
Tungsten	0.0321	134
Silver	0.0564	236
Copper	0.0923	386
Aluminum	0.215	900
Other Solids		
Brass	0.092	380
Granite	0.19	790
Glass	0.20	840
Ice (−10°C)	0.530	2220
Liquids		
Mercury	0.033	140
Ethyl alcohol	0.58	2430
Seawater	0.93	3900
Water	1.00	4180

Calor de Transformación

Calor que se requiere para un cambio de fase





La cantidad de energía por unidad de masa que se debe transferir en forma de calor a un sistema cuando la muestra experimenta un cambio de fase se llama CALOR DE TRANSFORMACION

$$Q = Lm.$$

Calor de Vaporización: Líquido a Gas

Calor de Fusión: Sólido a Líquido

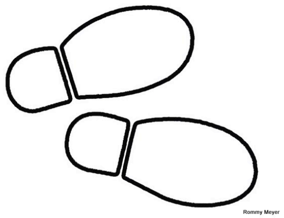
$$L_V = 539 \text{ cal/g} = 40.7 \text{ kJ/mol} = 2256 \text{ kJ/kg.}$$

$$L_F = 79.5 \text{ cal/g} = 6.01 \text{ kJ/mol} = 333 \text{ kJ/kg.}$$

	Melting		Boiling	
Substance	Melting Point (K)	Heat of Fusion L_F (kJ/kg)	Boiling Point (K)	Heat of Vaporization L_V (kJ/kg)
Hydrogen	14.0	58.0	20.3	455
Oxygen	54.8	13.9	90.2	213
Mercury	234	11.4	630	296
Water	273	333	373	2256
Lead	601	23.2	2017	858
Silver	1235	105	2323	2336
Copper	1356	207	2868	4730

Ejercicio

Cuánto calor debe absorber un cubo de hielo de masa 720 g a -10 °C para pasar a estado líquido a una temperatura de 15 °C



Pasos del proceso

1. Calentar el hielo
2. Derretir el hielo
3. Calentar el líquido

1. Calentar el hielo

$$Q_1 = c_{\text{ice}} m (T_f - T_i)$$
$$= (2220 \text{ J/kg} \cdot \text{K})(0.720 \text{ kg})[0°\text{C} - (-10°\text{C})]$$
$$= 15\,984 \text{ J} \approx 15.98 \text{ kJ}.$$

2. Derretir el hielo

$$Q_2 = L_F m = (333 \text{ kJ/kg})(0.720 \text{ kg}) \approx 239.8 \text{ kJ}.$$

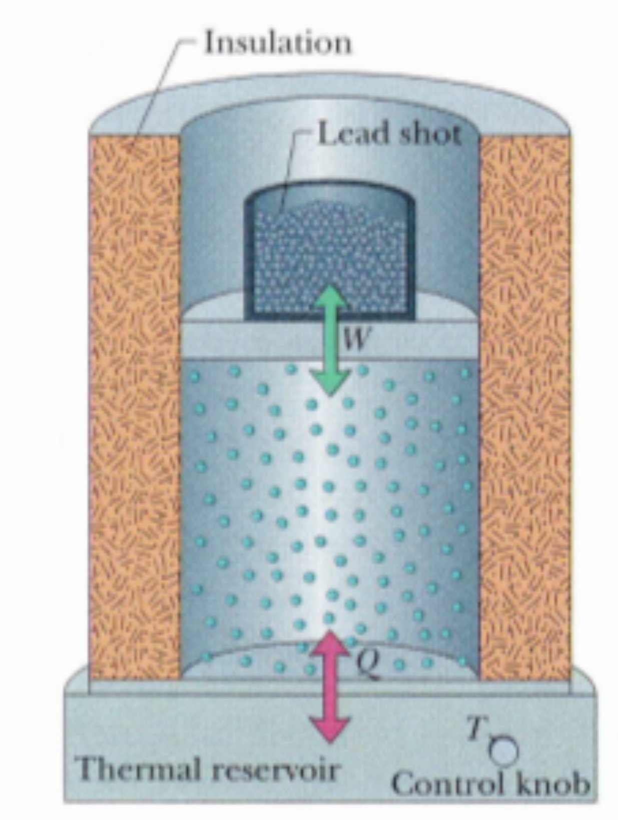
3. Calentar el líquido

$$Q_3 = c_{\text{liq}} m (T_f - T_i)$$
$$= (4190 \text{ J/kg} \cdot \text{K})(0.720 \text{ kg})(15°\text{C} - 0°\text{C})$$
$$= 45\,252 \text{ J} \approx 45.25 \text{ kJ}.$$

TOTAL

$$Q_{\text{tot}} = Q_1 + Q_2 + Q_3$$
$$= 15.98 \text{ kJ} + 239.8 \text{ kJ} + 45.25 \text{ kJ}$$
$$\approx 300 \text{ kJ}.$$

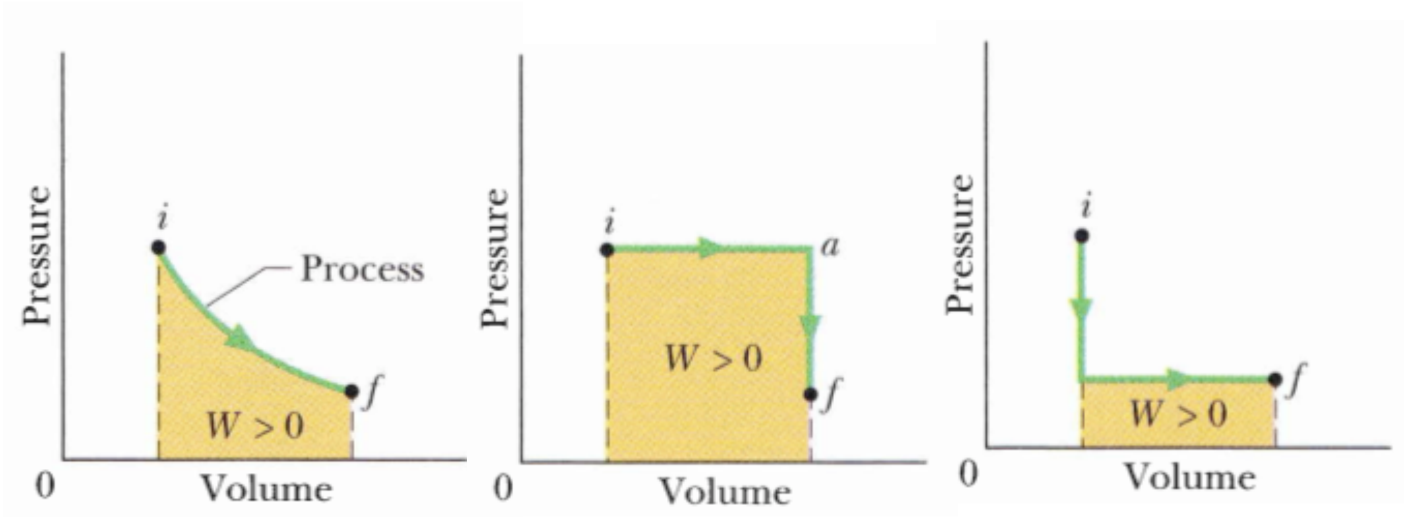
Una mirada detallada al calor y el trabajo

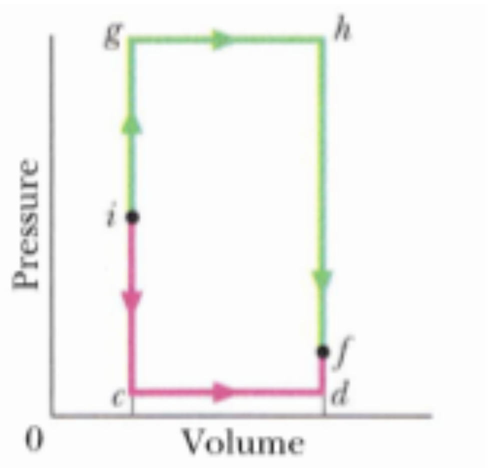


Proceso termodinámico: cambia un sistema de un estado inicial a un estado final

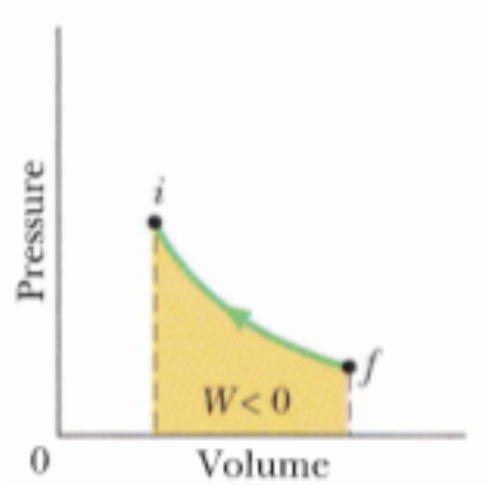
$$dW = \vec{F} \cdot d\vec{s} = (pA)(ds) = p(A\,ds) = p\,dV,$$

$$W = \int dW = \int_{V_i}^{V_f} p\,dV.$$

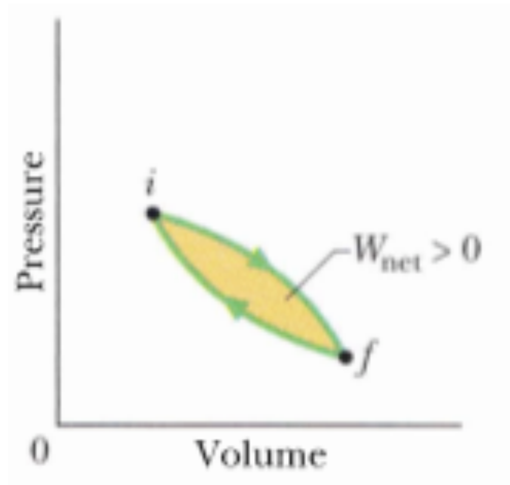




Pressure
Volume
0
g
h
i
f
c
d



Pressure
Volume
0
i
f
W < 0

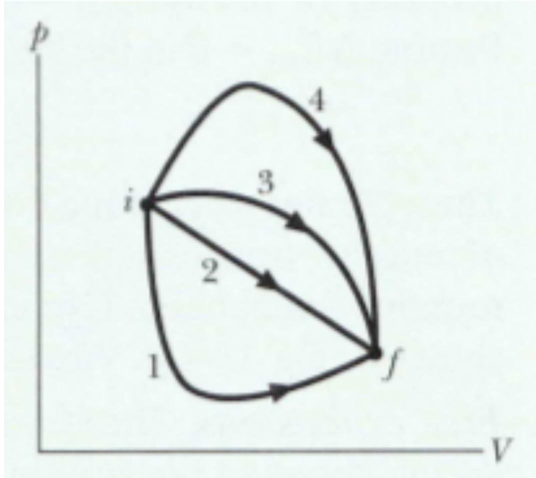


Pressure
Volume
0
i
f
W_net > 0

Primera Ley de la Termodinámica

$$\Delta E_{\text{int}} = E_{\text{int},f} - E_{\text{int},i} = Q - W$$

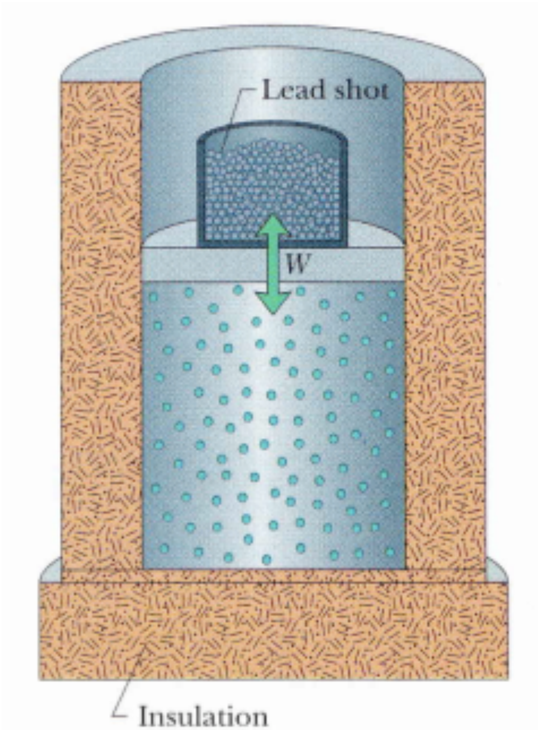
Solo depende de los estados inicial y final del sistema y no de latrayectoria



$$dE_{\text{int}} = dQ - dW$$

La energía interna de un sistema tiende a incrementar si se adiciona energía en forma de calor y tiene a disminuir si la energia se pierde en forma de trabajo hecho por el sistema.

Casos especiales de la primer Ley

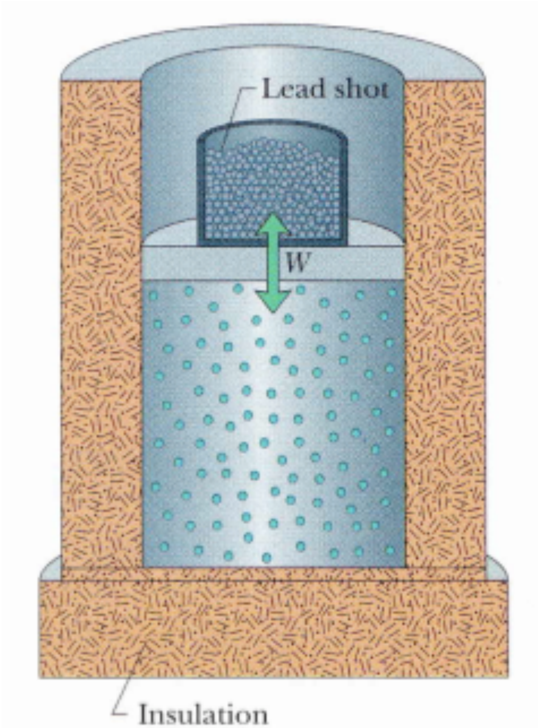


Proceso adiabático

Q=0

$$\Delta E_{\text{int}} = -W$$

Casos especiales de la primer Ley

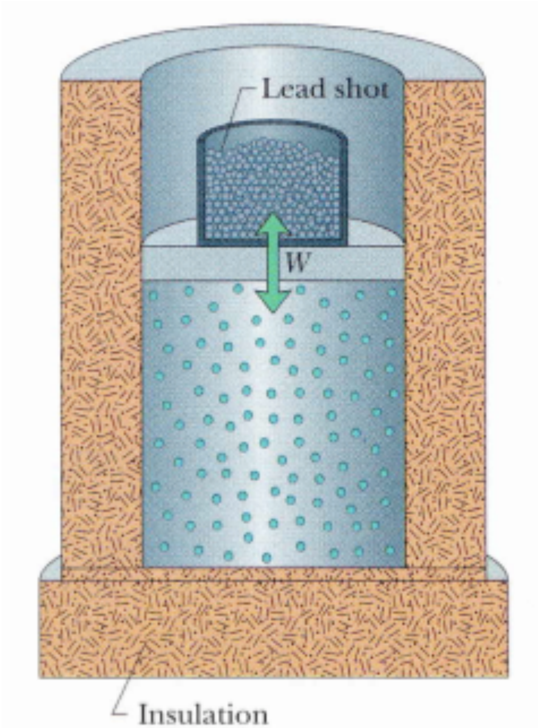


Proceso a volúmen constante

W=0

$$\Delta E_{\text{int}} = Q$$

Casos especiales de la primer Ley

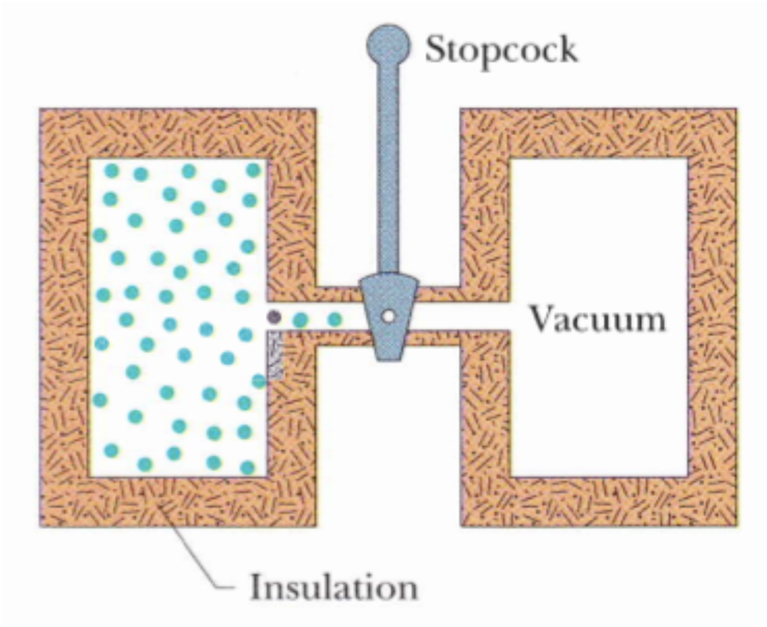


Proceso cíclico

$$\Delta E_{\text{int}} = 0$$

$$Q = W$$

Casos especiales de la primer Ley



Expansión libre

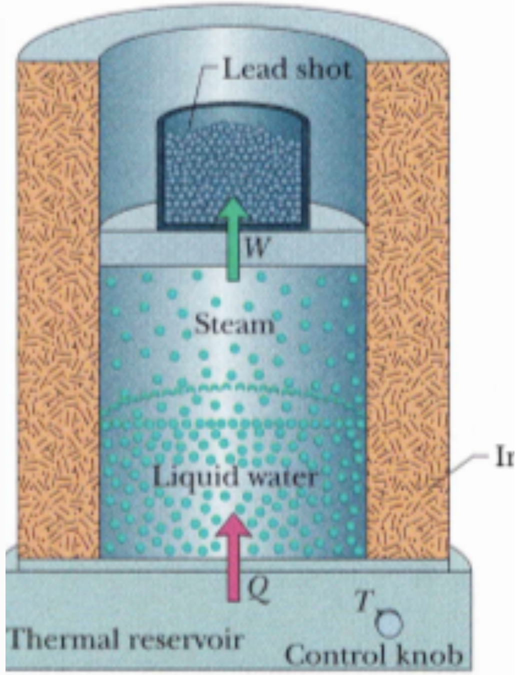
$$Q = W = 0,$$

$$\Delta E_{\text{int}} = 0$$

Process	Restriction	Consequence
Adiabatic	$Q = 0$	$\Delta E_{int} = -W$
Constant volume	$W = 0$	$\Delta E_{int} = Q$
Closed cycle	$\Delta E_{int} = 0$	$Q = W$
Free expansion	$Q = W = 0$	$\Delta E_{int} = 0$

Ejercicio

Let 1.00 kg of liquid water at 100°C be converted to steam at 100°C by boiling at standard atmospheric pressure (which is 1.00 atm or 1.01×10^5 Pa) in the arrangement of Fig. 18-17. The volume of that water changes from an initial value of 1.00×10^{-3} m^3 as a liquid to 1.671 m^3 as steam.



(a) How much work is done by the system during this process?

(b) How much energy is transferred as heat during the process?

(c) What is the change in the system's internal energy during the process?

(a) How much work is done by the system during this process?

$$W = \int_{V_i}^{V_f} p\, dV = p \int_{V_i}^{V_f} dV = p(V_f - V_i)$$

$$= (1.01 \times 10^5 \text{ Pa})(1.671 \text{ m}^3 - 1.00 \times 10^{-3} \text{ m}^3)$$

$$= 1.69 \times 10^5 \text{ J} = 169 \text{ kJ}. \qquad \text{(Answer)}$$

(b) How much energy is transferred as heat during the process?

$$Q = L_V m = (2256 \text{ kJ/kg})(1.00 \text{ kg})$$

$$= 2256 \text{ kJ} \approx 2260 \text{ kJ}.$$

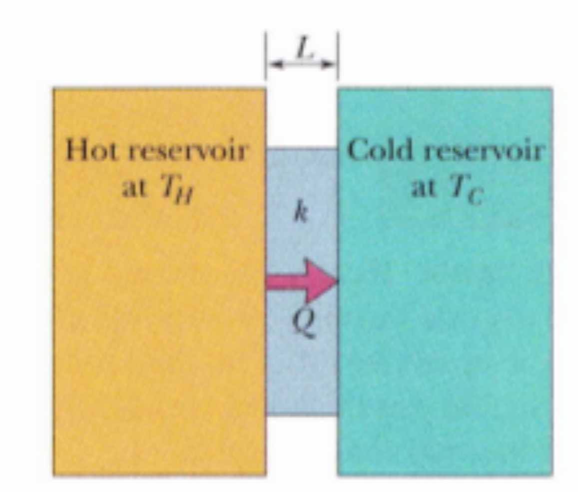
(c) What is the change in the system's internal energy during the process?

$$\Delta E_{\text{int}} = Q - W = 2256 \text{ kJ} - 169 \text{ kJ}$$

$$\approx 2090 \text{ kJ} = 2.09 \text{ MJ}.$$

Mecanismos de transferencia de calor

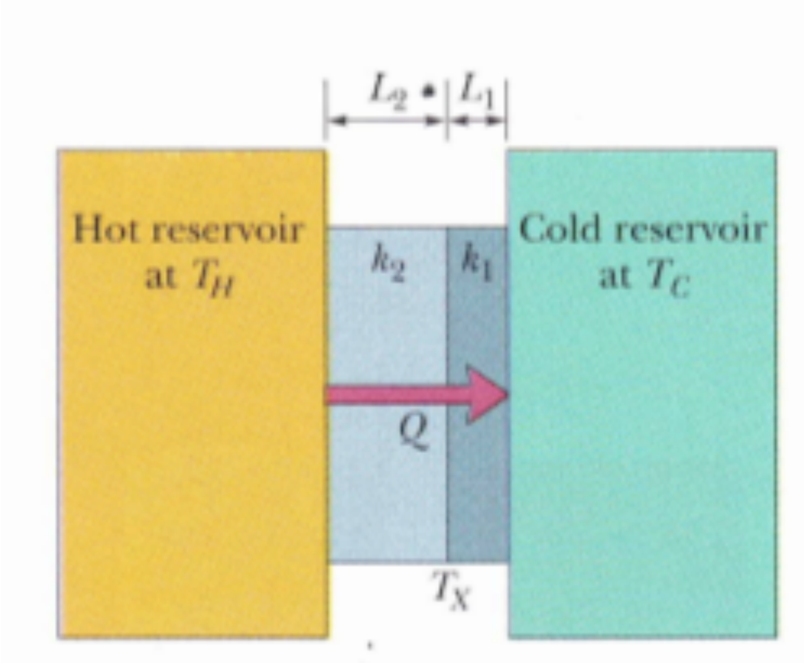
Conducción



$$P_{\text{cond}} = \frac{Q}{t} = kA\,\frac{T_H - T_C}{L},$$

k=conductividad térmica

Substance	k (W/m·K)
Metals	
Stainless steel	14
Lead	35
Iron	67
Brass	109
Aluminum	235
Copper	401
Silver	428
Gases	
Air (dry)	0.026
Helium	0.15
Hydrogen	0.18
Building Materials	
Polyurethane foam	0.024
Rock wool	0.043
Fiberglass	0.048
White pine	0.11
Window glass	1.0



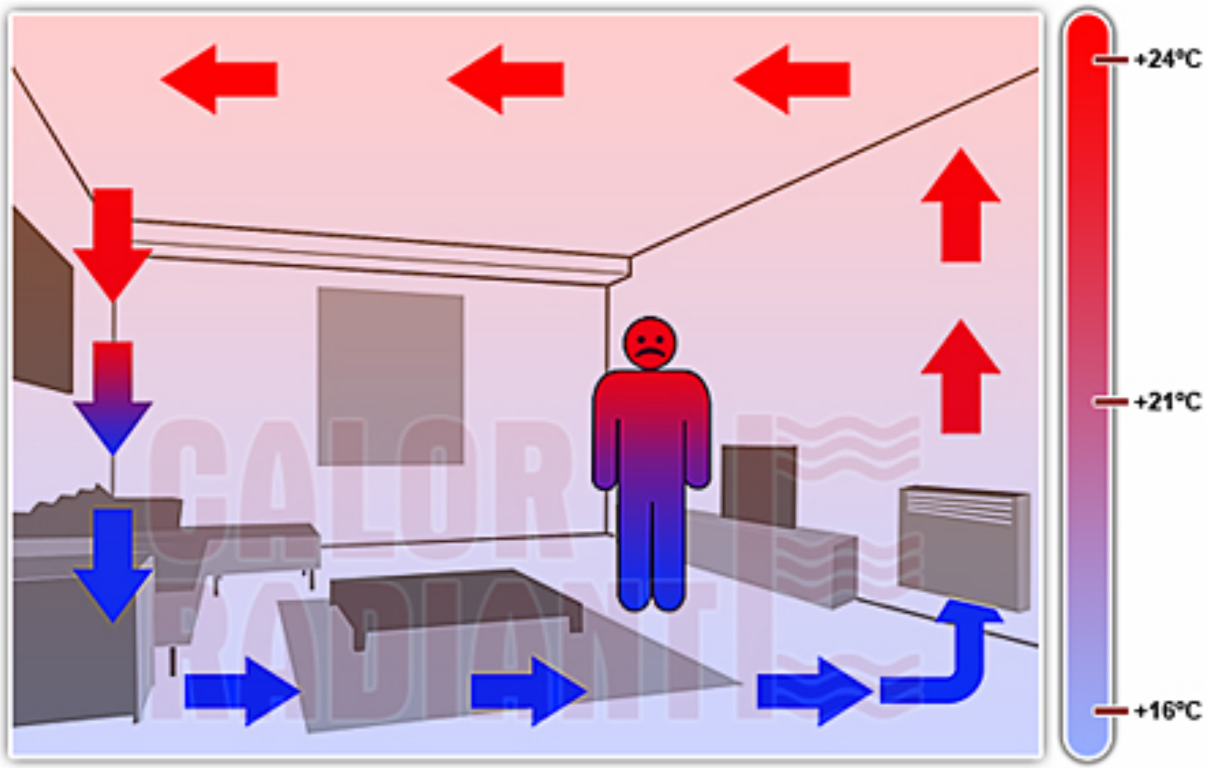
$$P_{cond} = \frac{k_2 A (T_H - T_X)}{L_2} = \frac{k_1 A (T_X - T_C)}{L_1}.$$

$$T_X = \frac{k_1 L_2 T_C + k_2 L_1 T_H}{k_1 L_2 + k_2 L_1}.$$

$$P_{cond} = \frac{A (T_H - T_C)}{L_1/k_1 + L_2/k_2}.$$

$$P_{cond} = \frac{A (T_H - T_C)}{\Sigma (L/k)}.$$

Convección

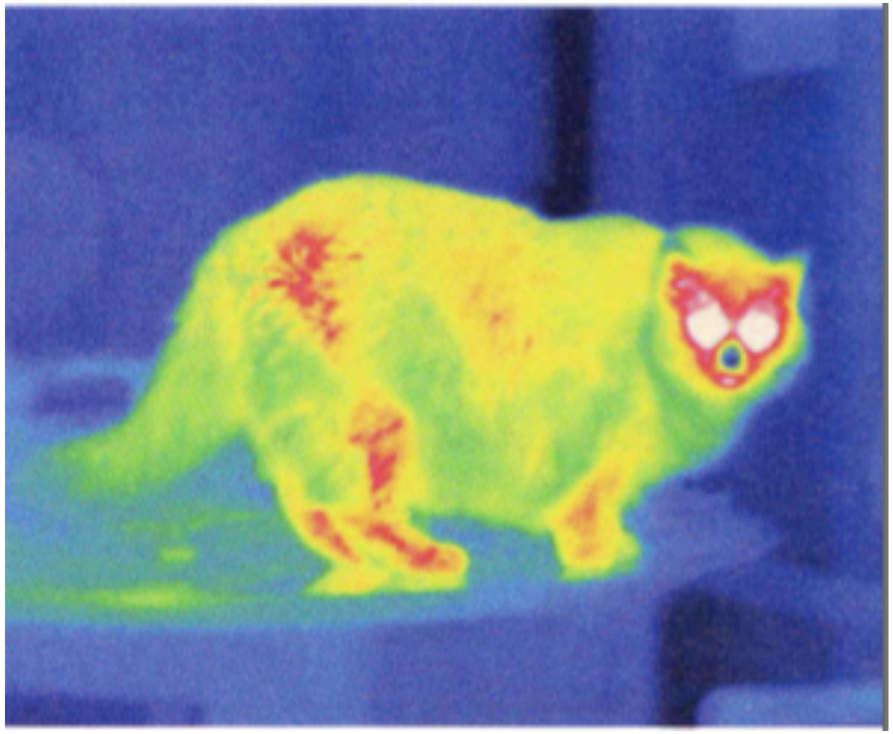


Radiación térmica

$$P_{\text{rad}} = \sigma \varepsilon A T^4.$$

$\sigma = 5.6704 \times 10^{-8}\ \text{W/m}^2 \cdot \text{K}^4$

constante de Stefan-Boltzmann



ε emisividad (entre 0 y 1 dependiendo de la superficie)

Interior Solar