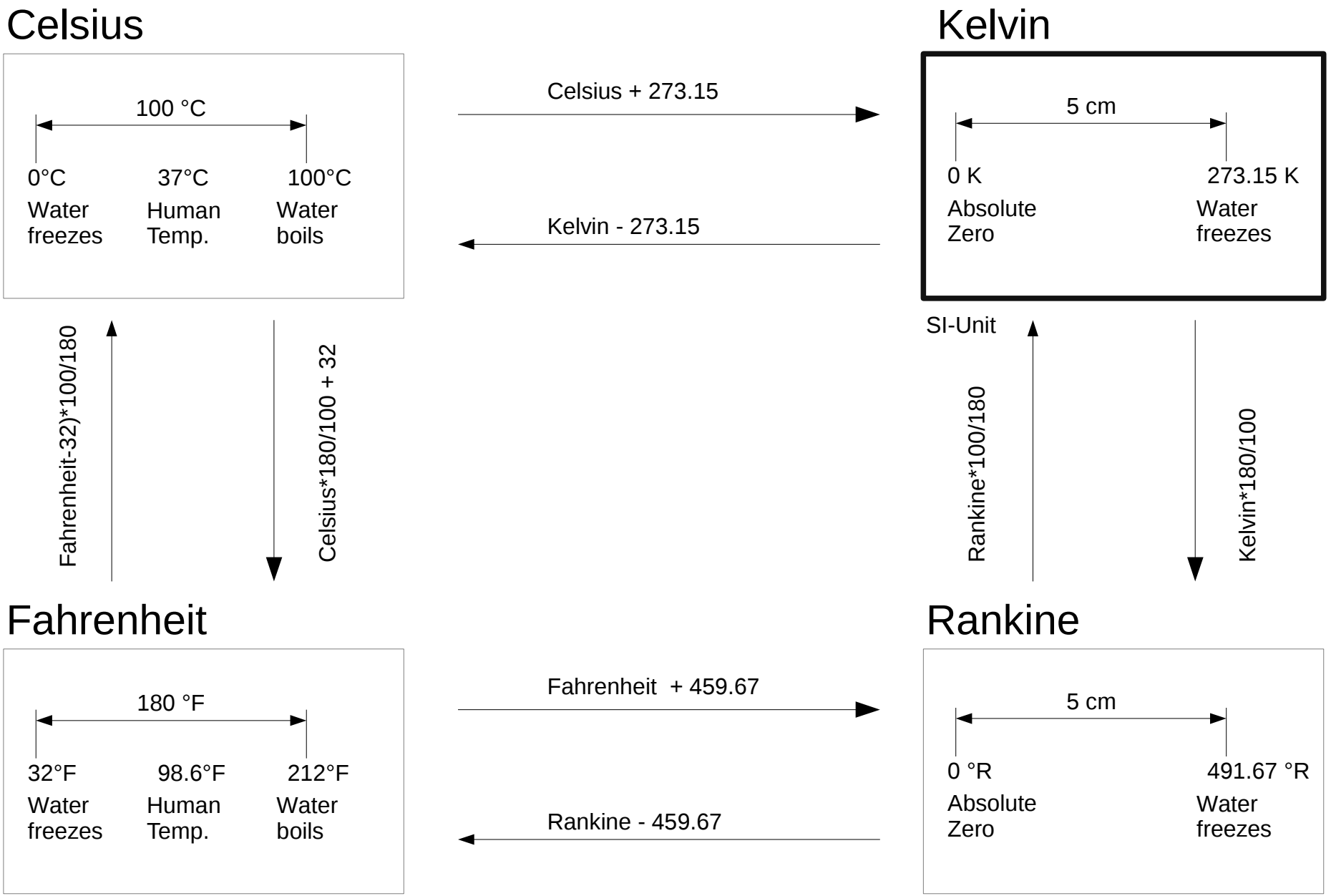
Thermodynamics

- **Temperature Scales**
- **Thermal Expansion**
- **Heat and Heat Transfer**
- **Latent Heat**

Temperature Scales



Thermal expansion

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

$$L_f = L_i + \Delta L$$

α	Coefficient of linear expansion
ΔT	Change in temperature
L_i	Initial length
L_f	Final length
ΔL	Change in length

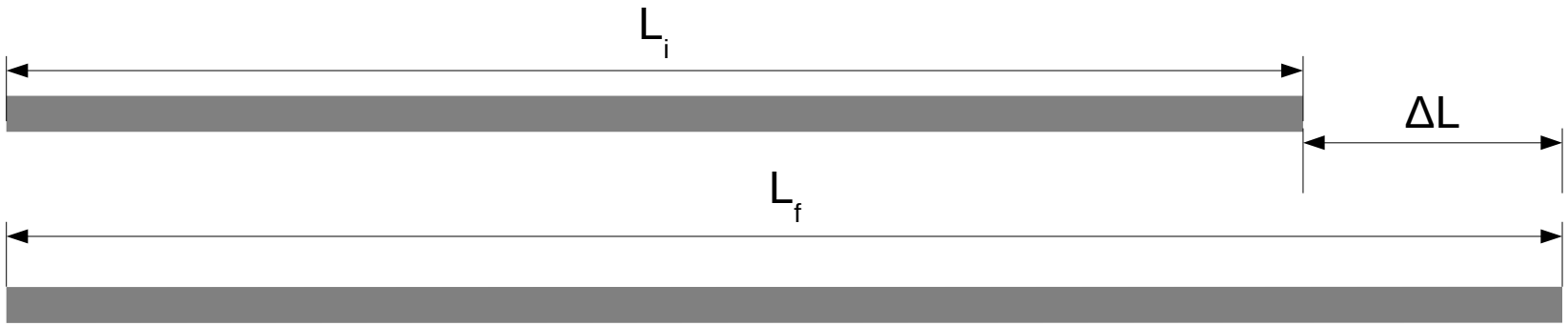


Image: "215533 Rails Buckled after Trestle Fire, Pe Ell, WA 1926 „ by Forest Service via Flickr
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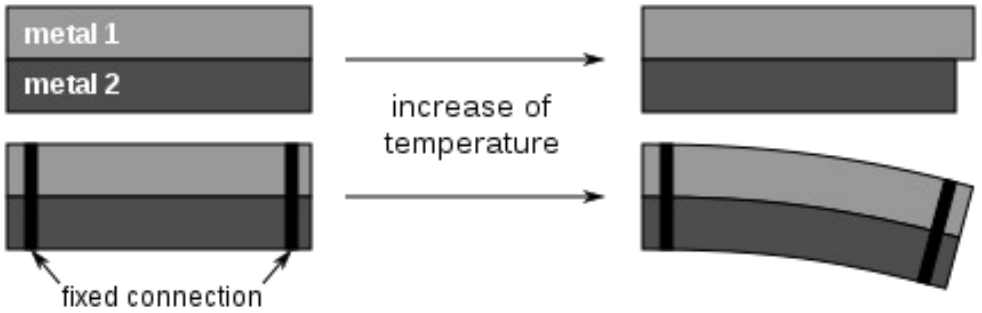
Thermal expansion – Application: Bang Bang Temperature Control

Bimetal



Source:
“Scheme of a bimetallic stripe” by Patrick87
Via Wikimedia
https://en.wikipedia.org/wiki/File:Bimetallic_stripe.svg
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→ Bimetal-Thermostats and “Bang-Bang” temperature-control

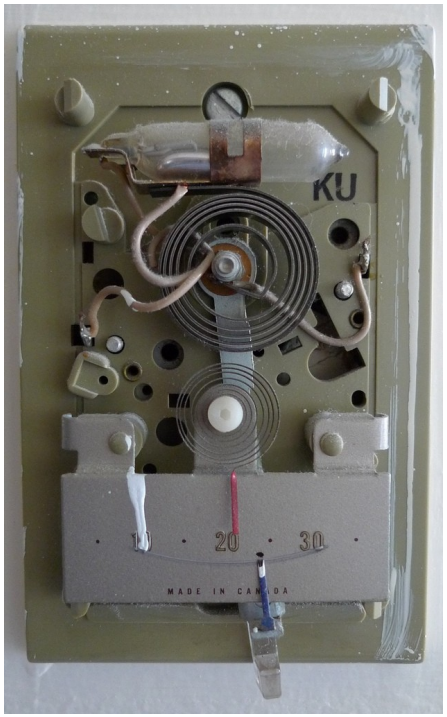

Image: “Thermostat”
By velkr0 via Flickr
https://www.flickr.com/photos/velkr0/3517080166/
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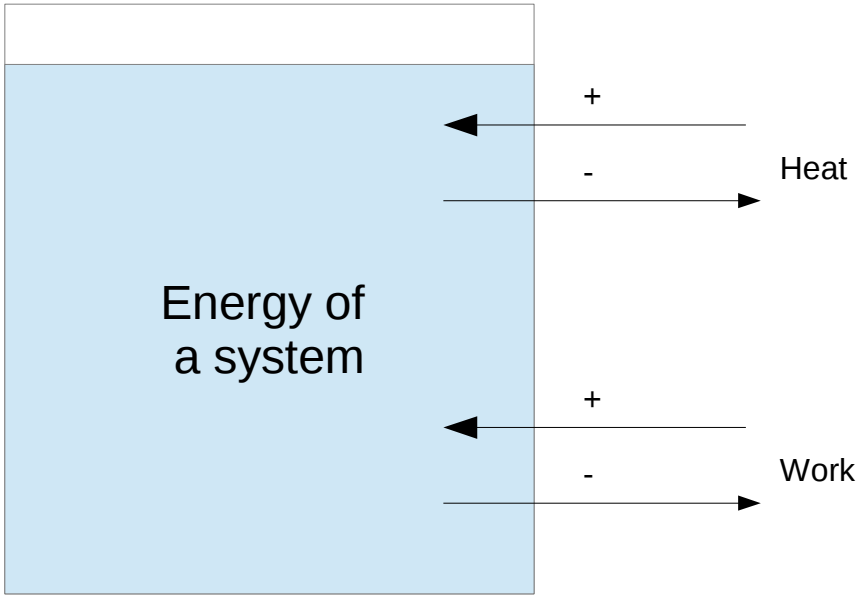
Heat and Heat transfer - 1st Law of Thermodynamics

$$E_{final} = E_{initial} + Q + W$$

$$E_{th} = m\,c\,T$$

E_{th}	Thermal Energy	[J]
m	Mass	[kg]
c	Specific heat capacity	[J/(kg K)
T	Temperature	[K]
Q	Heat	[J]
W	Work	[J]

Image: „Heat“ by Stefan Bracher



Heat and Heat transfer - Application

Heat Engine

$$E_{final} = E_{initial} + Q + W$$

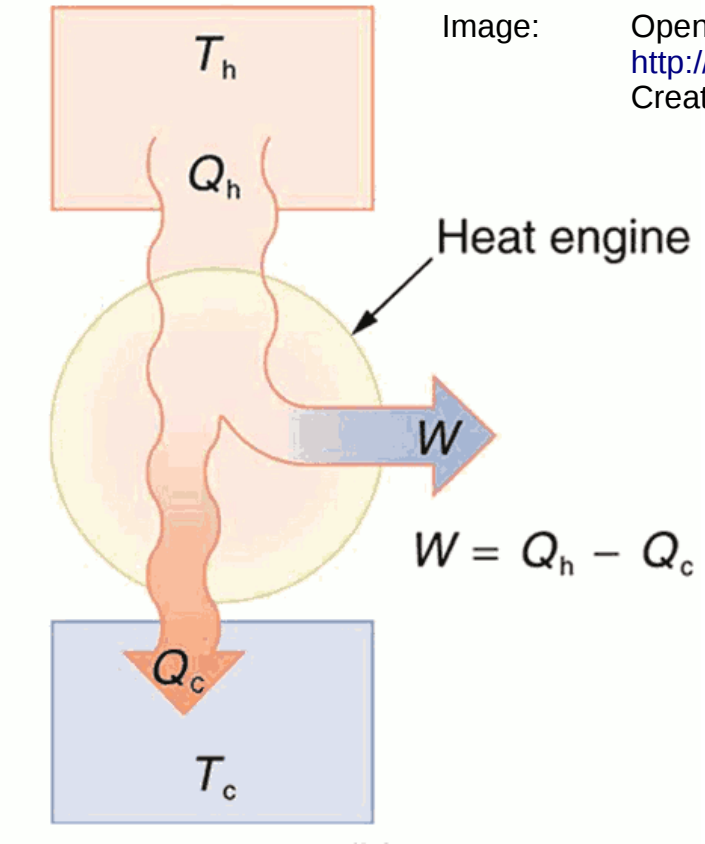


Image: OpenStax, College Physics. OpenStax CNX. 4. Nov. 2016
http://cnx.org/contents/Ax2o07Ul@9.39:_RSOYYkJ@4/Introduction-to-the-Second-Law
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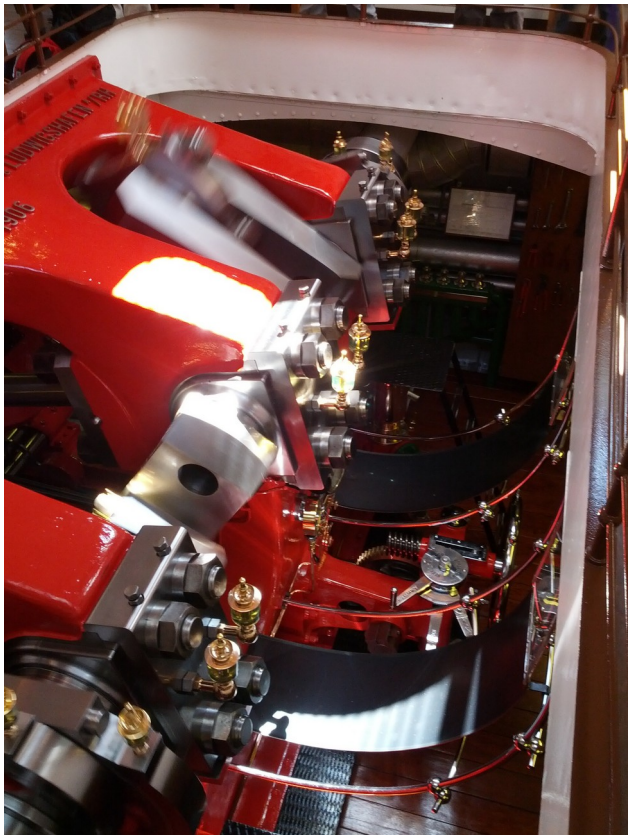


Video: Steam engine of the paddle-boat “Schiller” (Stefan Bracher)
https://www.youtube.com/watch?v=hxkt8po0slE

Heat and Heat transfer - Units

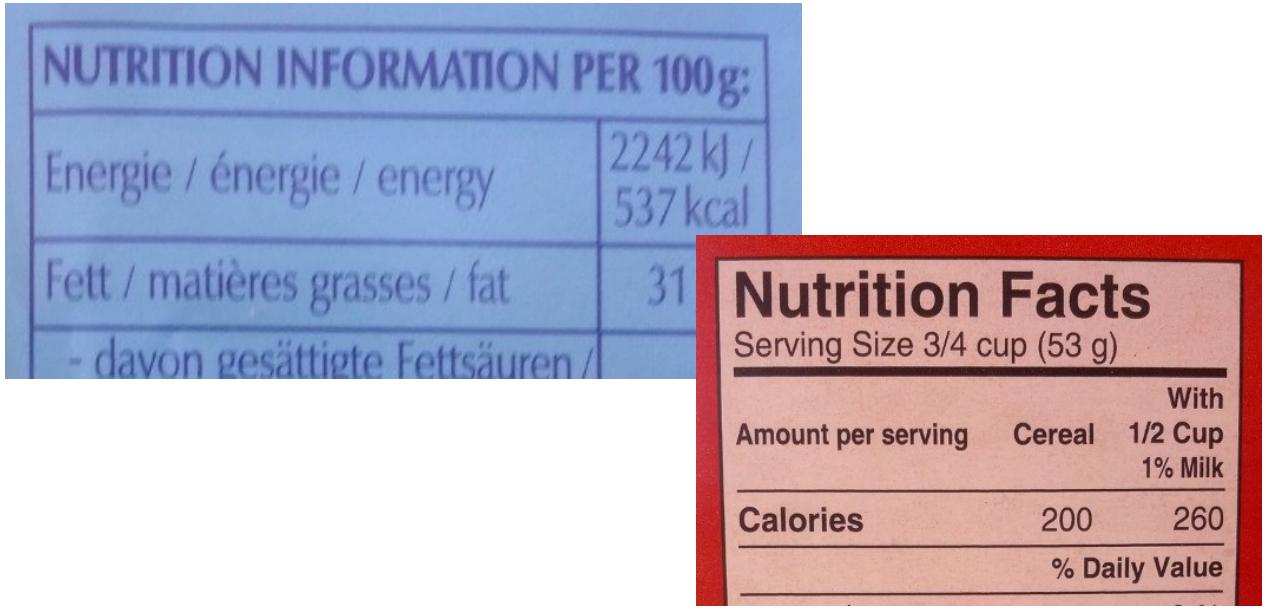
SI-Unit: Joules

Other Units:

1 kWh = 3.6 x 10^6 Joules

1 calorie [cal] = 4.184 Joules [J]

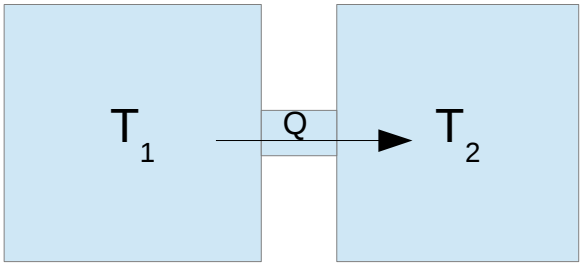
1 Calorie [Cal]) = 1 kilocalorie [kcal] = 1000 calories [cal]



Images: Nutrition information on food items (Stefan Bracher)

Heat and Heat transfer - 2nd Law of Thermodynamics

Heat always flows from hot to cold



$T_1 > T_2$

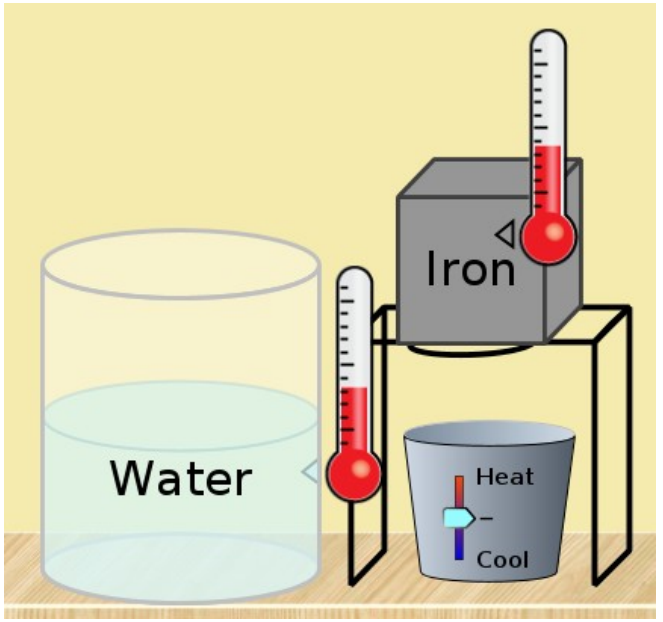
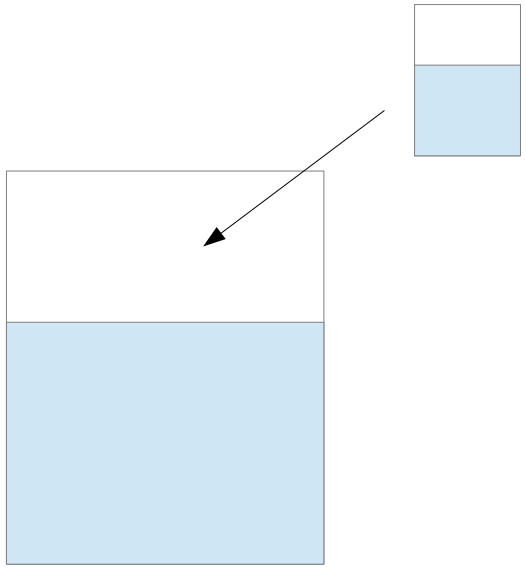


Image: Phet Simulation „Energy Forms and Changes“
https://phet.colorado.edu/en/simulation/legacy/energy-forms-and-changes

Heat and Heat transfer - Application

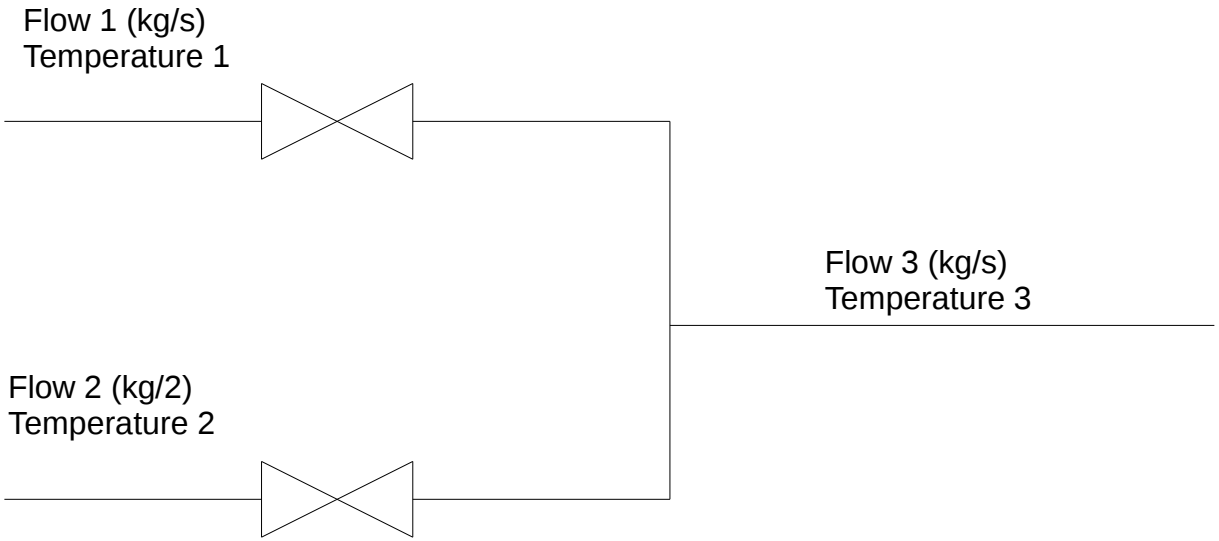
Final Temperature:



1.0 kg of water at 100°C are added to
60. kg of water at 10°C.

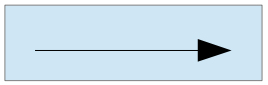
What is the final temperature of the mix?

Water temperature control

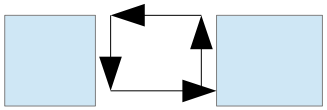


Heat and Heat transfer – Modes of heat transfer

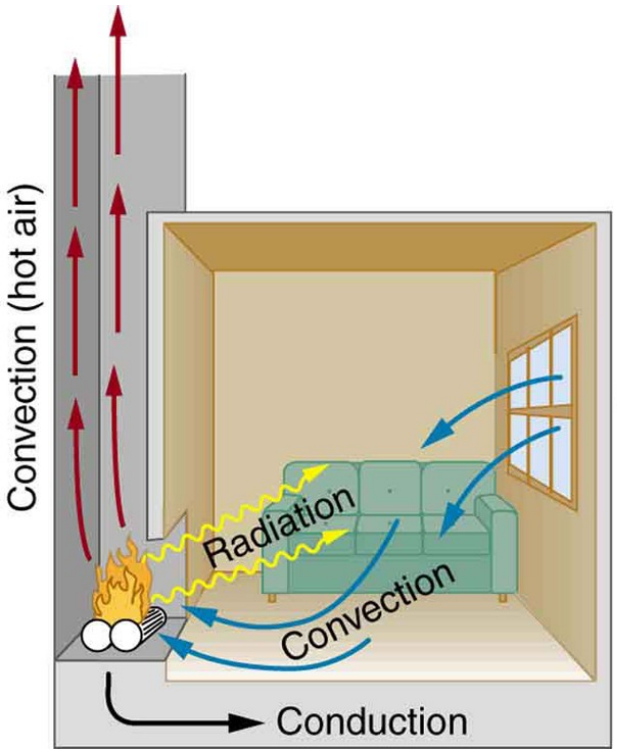
Conduction



Convection



Radiation



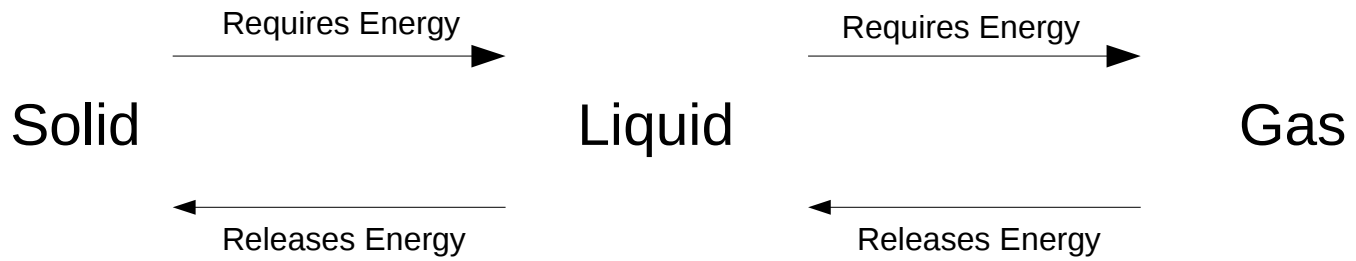
Convection around windows and doors (cold air)

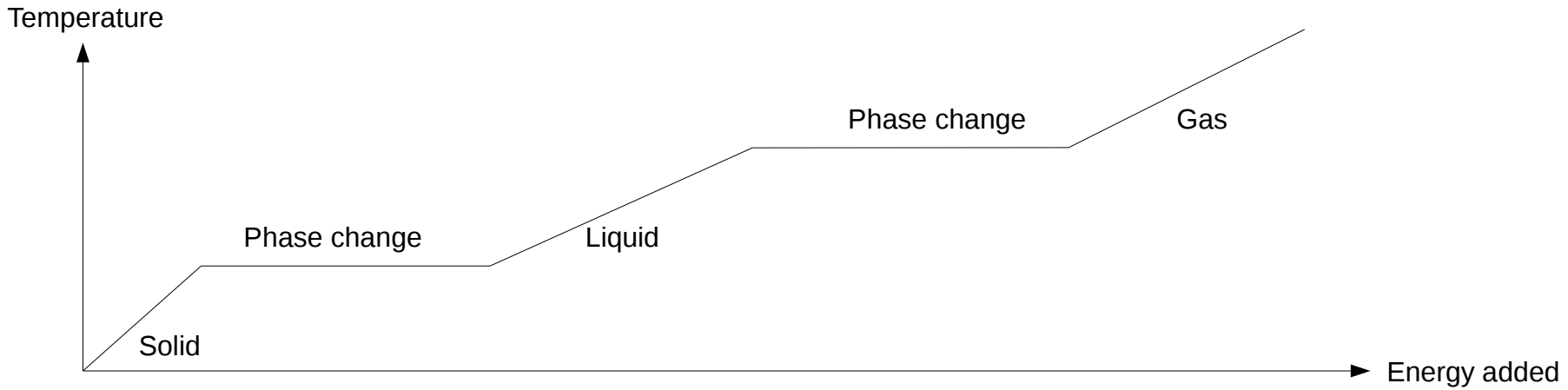
Image: OpenStax, College Physics. OpenStax CNX. 4. Nov. 2016
http://cnx.org/contents/Ax2o07Ul@9.39:Q1FnCAex@3/Heat-Transfer-Methods

Latent Heat – Energy required or released for phase changes

$$Q = mL$$

m	Mass	[kg]
L	Latent heat	[J/kg]
Q	Heat	[J]





Latent Heat – Application

Cooling of Champagne :

How do you cool a bottle of Champagne the fastest?

1) Cover it with ice
2) Submerge it in cold water
3) Submerge it in a mix of cold water and ice
4) Submerge it in a mix of cold water, salt and ice
5) Put it in the freezer

Additional Resources

- Temperature in “College Physics” Chapter 13.1
  http://cnx.org/contents/Ax2o07Ul@9.39:2ou0Jg2y@3/Temperature

- Thermal Expansion in “College Physics” Chapter 13.2
  http://cnx.org/contents/Ax2o07Ul@9.39:C20NI-lv@5/Thermal-Expansion-of-Solids-an

- Heat and Heat Transfer Methods in “College Physics” Chapter 14
  http://cnx.org/contents/Ax2o07Ul@9.39:eJLN3YM-@3/Introduction-to-Heat-and-Heat-

Questions (Chap 13): 1, 2, 5, 7
Problems (Chap 13): 1, 3, 5, 7, 9, 15, 17

Questions (Chap 14): 2, 4, 8, 9, 13, 17
Problems (Chap 14): 1, 3, 5, 9, 11, 14, 16, 24