A wide-angle photograph of a winter landscape. The foreground is a snow-covered field with some sparse, dry vegetation. In the middle ground, there are several wooden structures, possibly remnants of a farm or ranch, including a partially collapsed wooden frame and a structure with a corrugated metal roof. The background features a large, forested mountain with patches of snow on its slopes. The sky is clear and blue.

# PSD Weather and Climate Course Day 2

*It's cold because it snowed.*

## DETAILS

The course will meet on 5 Thursday evenings, for 3 hours per session:

- Thursday, February 4, 5:00 – 8:00 PM
- Thursday, February 18, 5:00 – 8:00 PM
- Thursday, March 4, 5:00 – 8:00 PM
- Thursday, March 25, 5:00 – 8:00 PM
- Thursday, April 1, 5:00 – 8:00 PM

Each class will be a mix of experimentation, discussion, and explanation.

## SIGNING UP

You will need to sign up for CSU credit to take part in this course. Here is a link to the CSU registration page:

- [CSU / PSD Science of Weather and Climate Course](#)

PSD is covering the cost of your credit, so you won't be charged.

## SCHEDULE

*Links will be live shortly before the course begins*

### Day 1: Energy & the EM spectrum

- Zoom link: <https://zoom.us/j/92574585808>
- [Outline of day's activities with links to documents](#)
- [Link to upload daily writing assignment](#)

### Day 2: Energy in the Earth System

- Zoom link: <https://zoom.us/j/92574585808>
- Outline of day's activities with links to documents (link available soon)
- [Link to upload daily writing assignment](#)

### Day 3: Air, Water & Clouds

- Zoom link: <https://zoom.us/j/92574585808>
- Outline of day's activities with links to documents (link available soon)
- [Link to upload daily writing assignment](#)

### Day 4: Weather: Local and Global

- Zoom link: <https://zoom.us/j/92574585808>
- Outline of day's activities with links to documents (link available soon)
- [Link to upload daily writing assignment](#)

### Day 5: Climate and Climate Change

- Zoom link: <https://zoom.us/j/92574585808>
- Outline of day's activities with links to documents (link available soon)
- Final project
- Final course survey

## THE SCIENCE OF WEATHER AND CLIMATE: DAY 1

### Introductions & Zoom Details

#### Course & Content Overview

- Details
- Overview of course structure / assignment / credit / instructional approach / mixing / questions and suggestions

#### Engage / Explore / Explain: Energy & Radiation

- Day 1 slides: [Energy, light & matter](#)
- Energy concepts: [What is energy?](#)
- The basic energy model
- Numbers & efficiency: [How much energy does it take to perform a task?](#)
- Electrical appliances: [Measuring energy and power](#)

#### Engage / Explore

- Energy and light: [Writing with light](#)

#### Explain: EM Spectrum

- Question: [How big is light?](#)
- Scales of energy and wavelength
- Interaction of electromagnetic waves with matter

#### Engage / Explore / Explain: EM Radiation

- The visible spectrum: [Using the rainbow glasses](#)
- Photon energy: [What is the difference between red light and blue light?](#)
- Beyond the rainbow, part I (Infrared filter): [What's beyond the rainbow?](#)
- Beyond the rainbow, part II (UV laser pointer + stuff that fluoresces)
- Astronomy connection: [Would you get a sunburn on Mars?](#)
- Thermal sensor: [What does it measure?](#)

#### Extend

- Things to try for next week

#### Evaluate: Today's Writing Assignment

- Write and [upload](#) answers to the following questions:
  - What are the main lessons from this session's activities and discussions?
  - What questions or uncertainties about this material do you still have?
  - What did this session make you wonder about—what questions did it raise?

# Energy comes in many different forms.

Mechanical energy:



Thermal energy:



Other forms include:

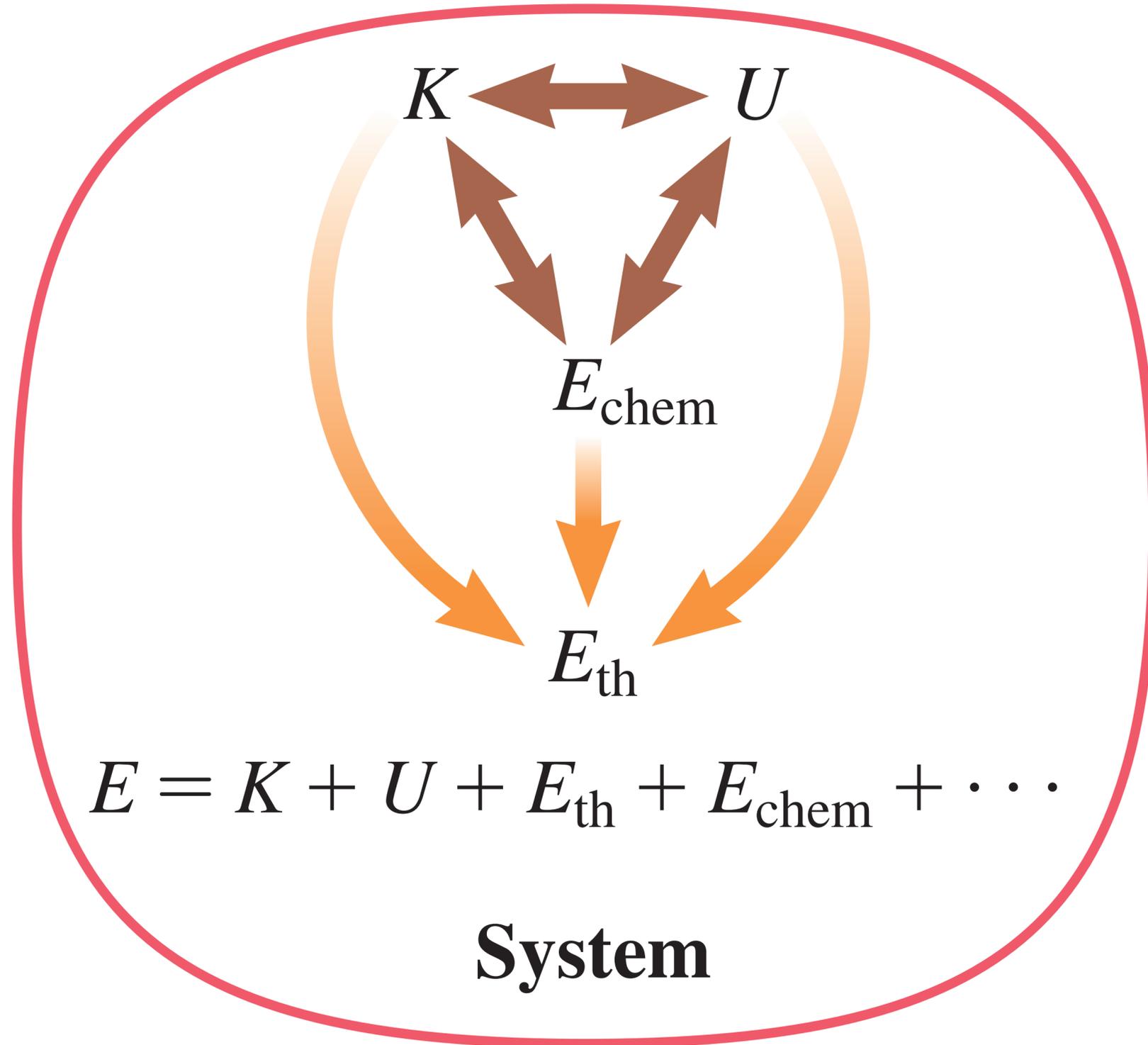


$E_{chem}$



$E_{nuclear}$

# The Basic Energy Model



# Modes of Heat Transfer

Conduction



Convection



Radiation



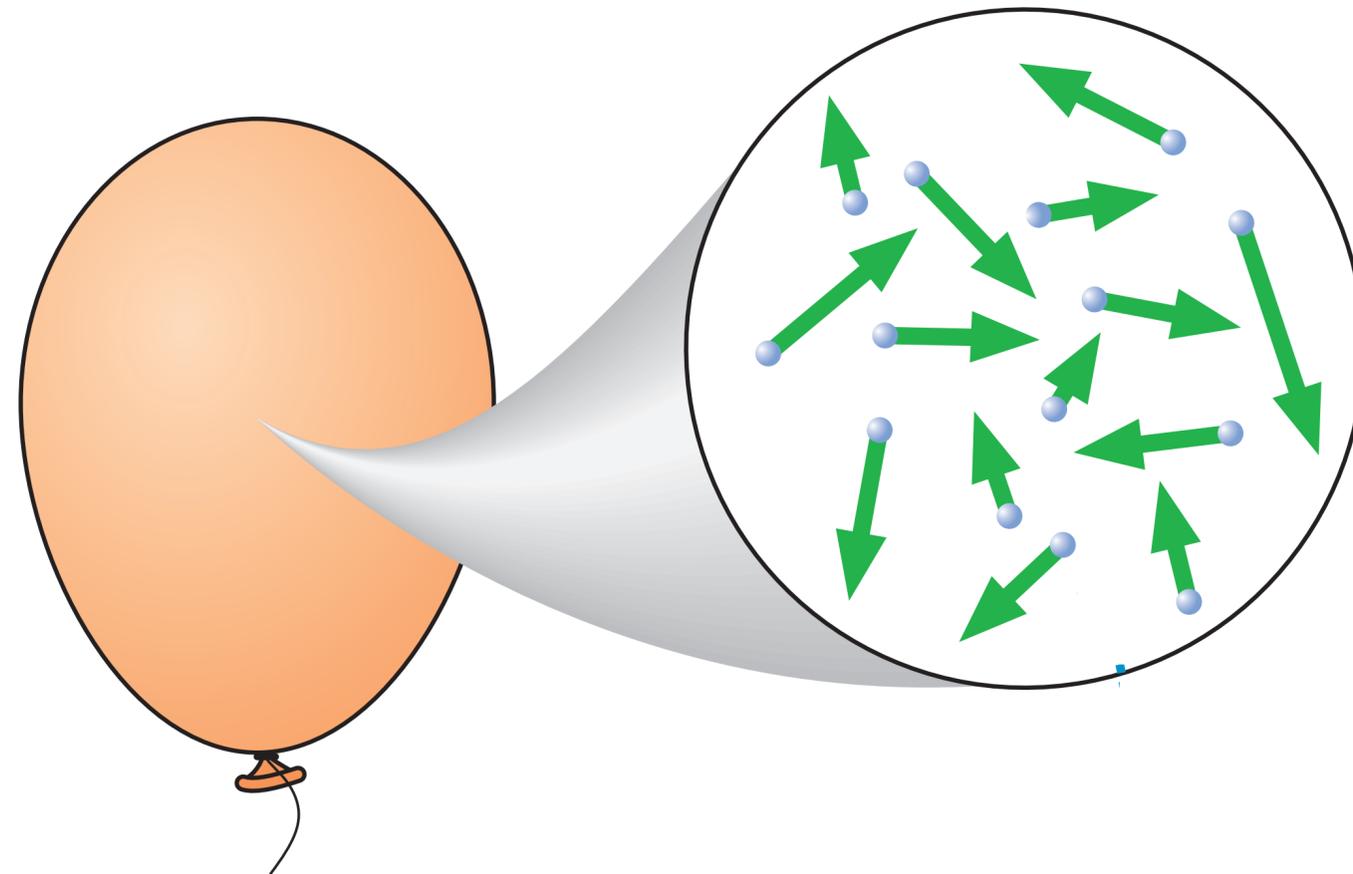
Evaporation

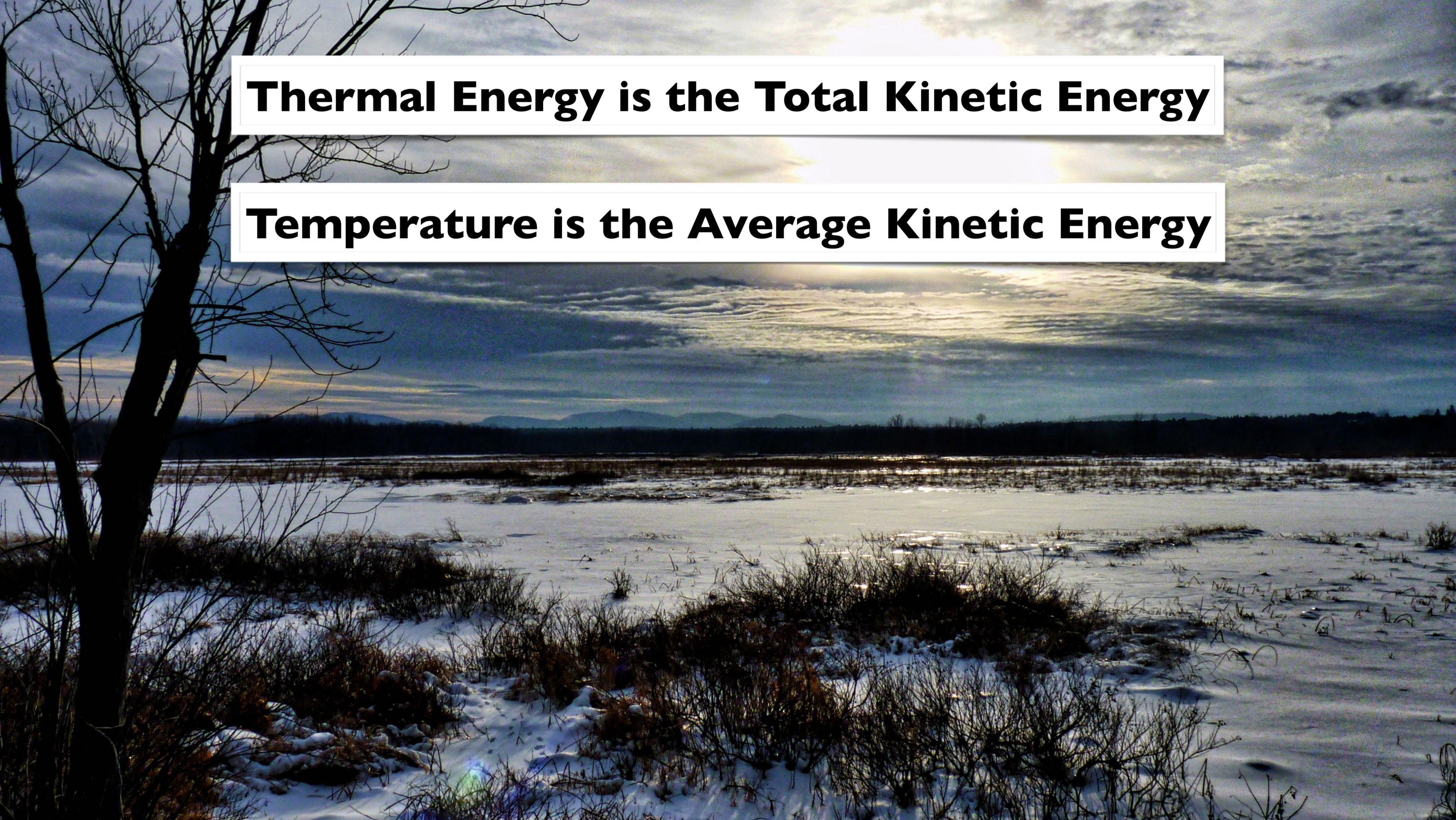


# Thermal Energy



**Thermal Energy**  
**is**  
**Kinetic Energy of Atoms and Molecules**





**Thermal Energy is the Total Kinetic Energy**

**Temperature is the Average Kinetic Energy**

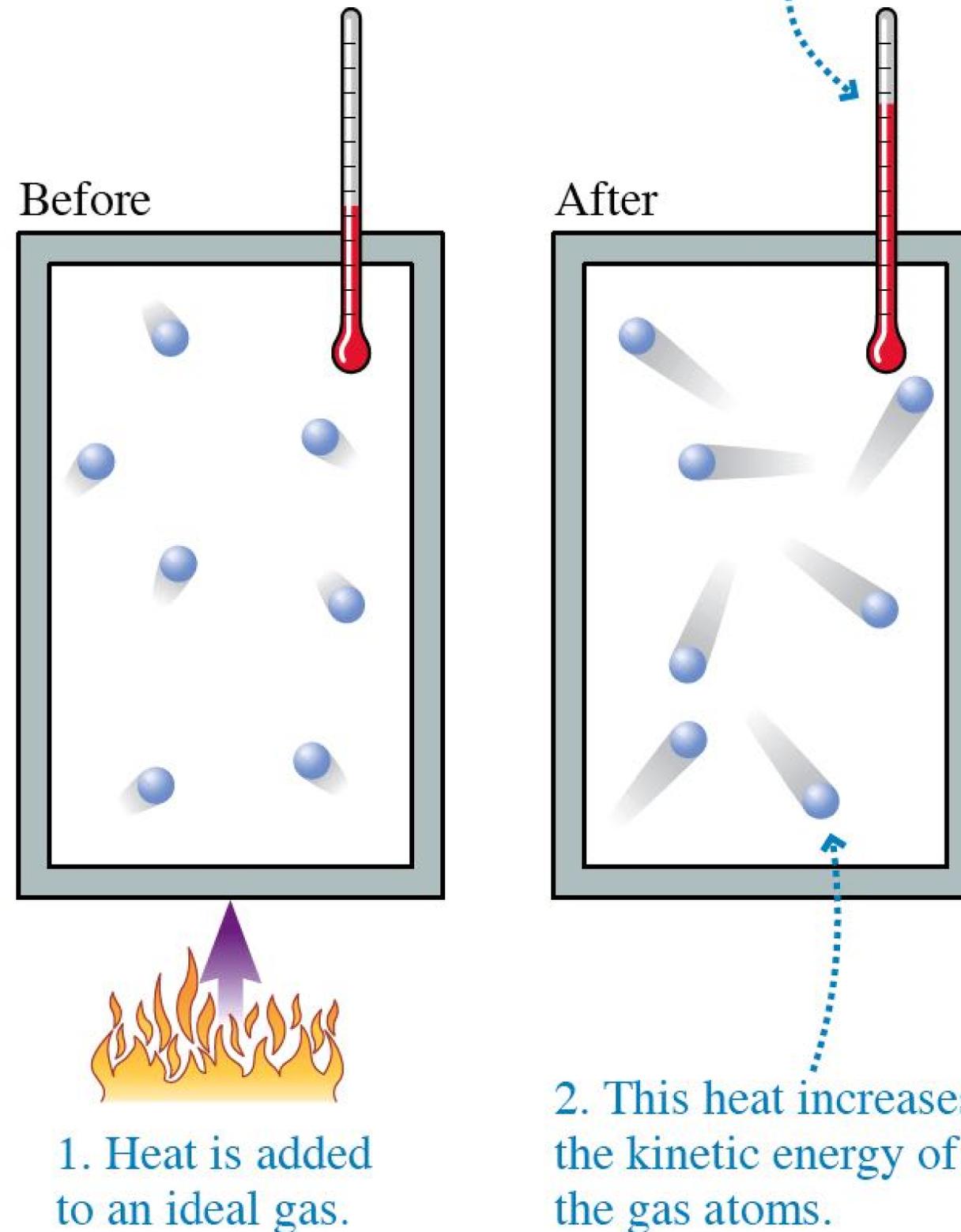
# The Ideal Gas Model

$$T = \frac{2}{3} \frac{K_{\text{avg}}}{k_B}$$

$$E_{\text{th}} = \frac{3}{2} N k_B T$$

Boltzmann's constant:

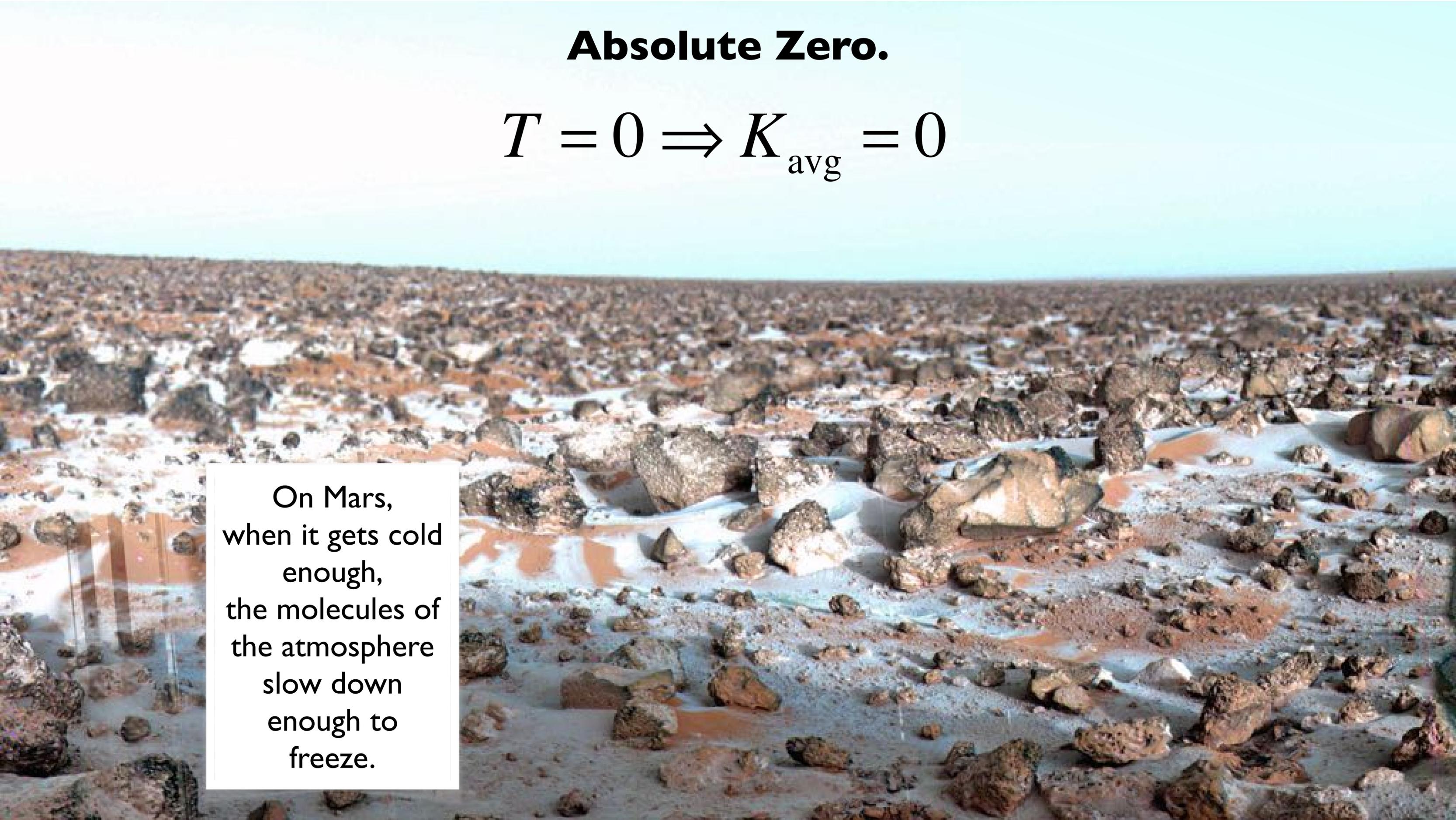
$$k_B = 1.38 \times 10^{-23} \text{ J/K}$$



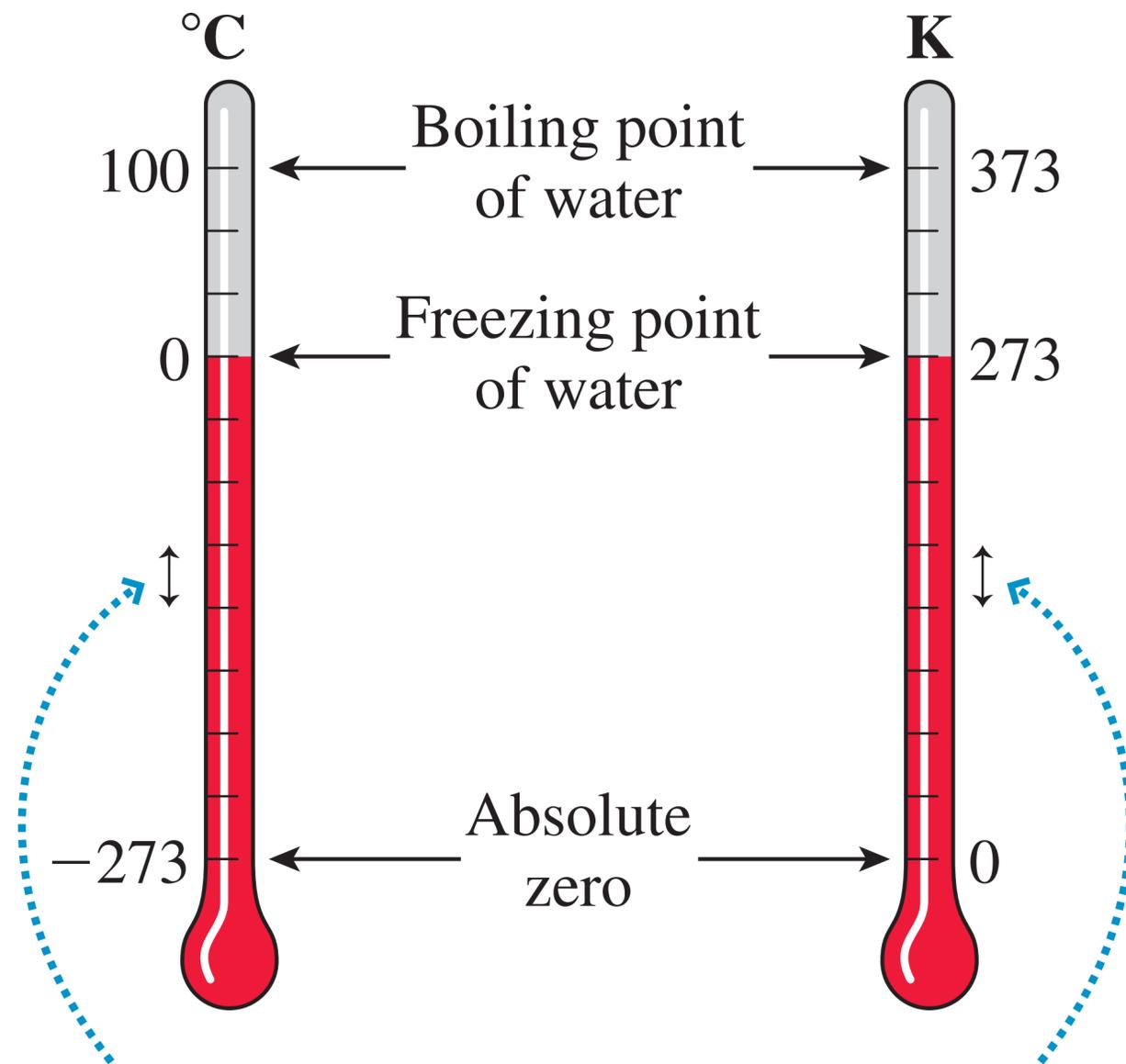
## Absolute Zero.

$$T = 0 \Rightarrow K_{\text{avg}} = 0$$

On Mars,  
when it gets cold  
enough,  
the molecules of  
the atmosphere  
slow down  
enough to  
freeze.



# Temperature Scales



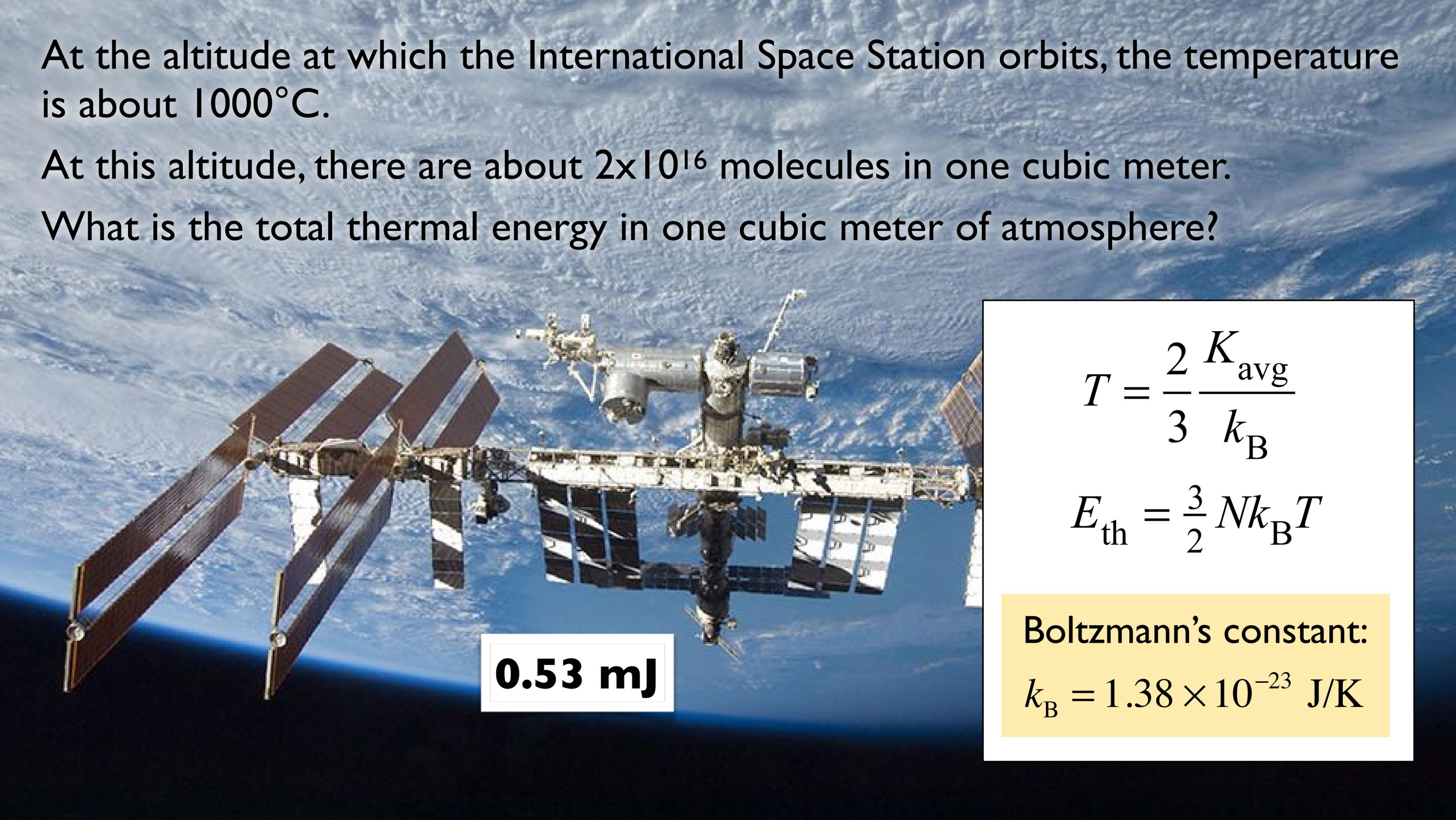
In physics, " $T$ " means a temperature in kelvin.

Temperature *differences* are the same on the Celsius and Kelvin scales. The temperature difference between the freezing point and boiling point of water is  $100^{\circ}\text{C}$  or  $100\text{ K}$ .

At the altitude at which the International Space Station orbits, the temperature is about  $1000^{\circ}\text{C}$ .

At this altitude, there are about  $2 \times 10^{16}$  molecules in one cubic meter.

What is the total thermal energy in one cubic meter of atmosphere?

A photograph of the International Space Station (ISS) in orbit above Earth's blue atmosphere. The station's complex structure, including large solar panel arrays and various modules, is clearly visible against the dark background of space.

**0.53 mJ**

$$T = \frac{2}{3} \frac{K_{\text{avg}}}{k_B}$$

$$E_{\text{th}} = \frac{3}{2} N k_B T$$

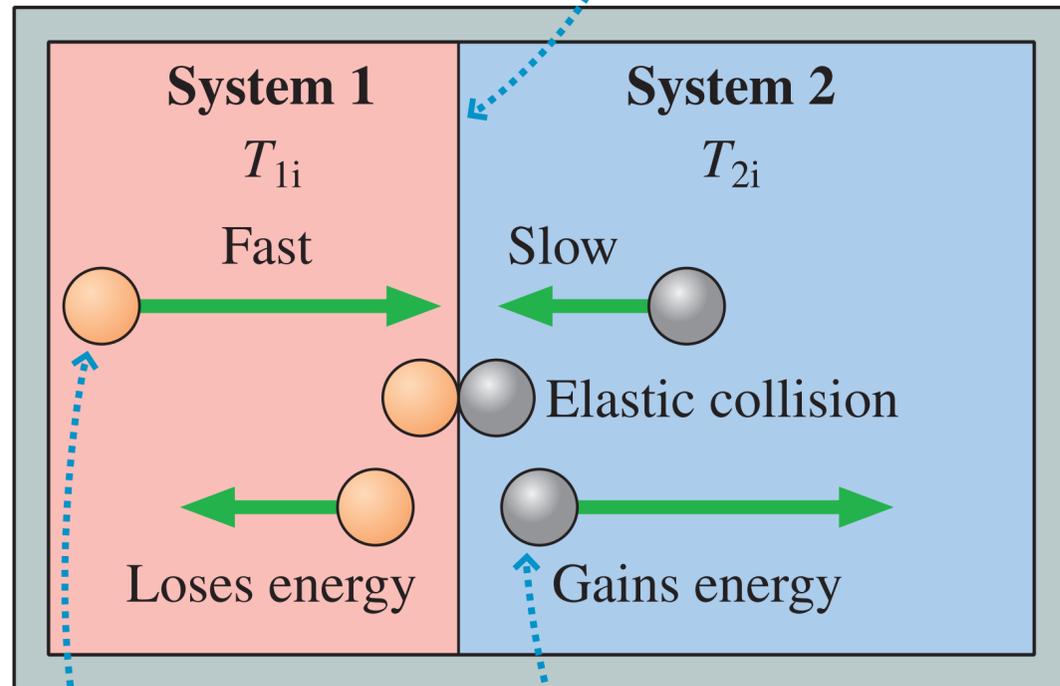
Boltzmann's constant:

$$k_B = 1.38 \times 10^{-23} \text{ J/K}$$

# Collisions transfer energy, until the temperatures are the same.

Insulation prevents heat from entering or leaving the container.

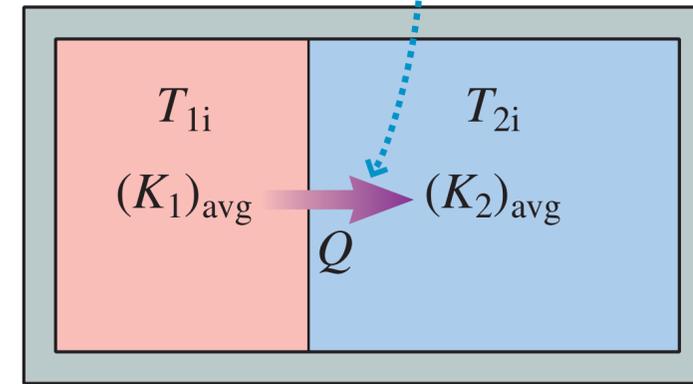
A thin barrier prevents atoms from moving from system 1 to 2 but still allows them to collide.



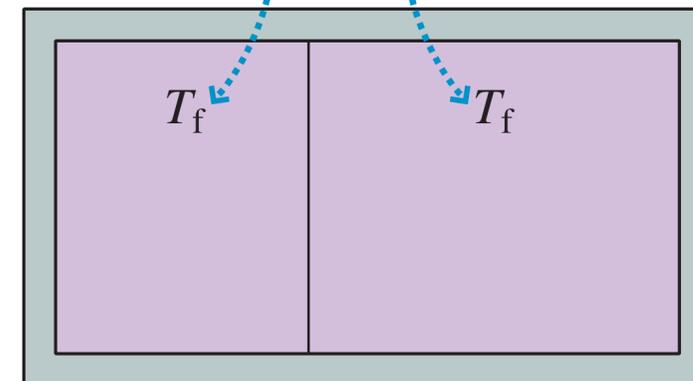
System 1 is initially at a higher temperature, and so has atoms with a higher average speed.

Collisions transfer energy to the atoms in system 2.

Collisions transfer energy from the warmer system to the cooler system. This energy transfer is heat.



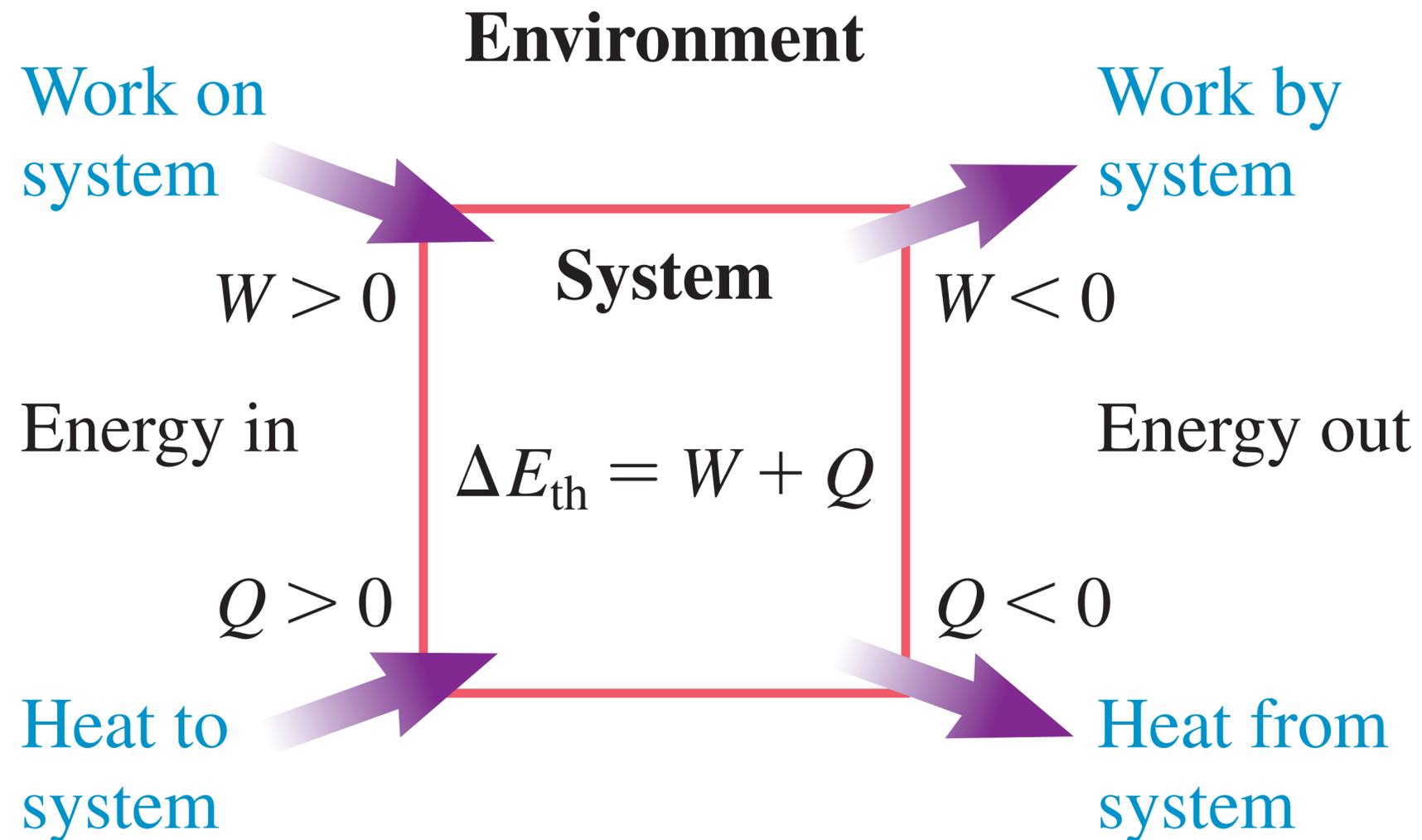
Thermal equilibrium occurs when the systems have the same average kinetic energy and thus the same temperature.



**First law of thermodynamics** For systems in which only the thermal energy changes, the change in thermal energy is equal to the energy transferred into or out of the system as work  $W$ , heat  $Q$ , or both:

$$\Delta E_{\text{th}} = W + Q \quad (11.8)$$

Not a  
new law of  
physics.



**If you leave a ceiling fan running during the day, it will warm up the room it's in.**

***Explain why.***





**NOTICE**  
 1. SEAT CONTAINER ON MOTOR BEFORE LOADING FOR USE.  
 2. TO TURN ON - REVERSE BACK AND FORTH ONCE ONLY!  
 3. FLASH WHEN REVERSING IS NORMAL.

**-FOR KNEADING BREAD-**  
 DON'T TAKE HOLD OF LEVER. MAKE A FIST AND TAP THE LEFT HAND CONTROL DOWN 3 OR 4 TIMES. INSTANTLY RELEASING TO FORM A BALL OF DOUGH. THE POWER SHOULD TURN OFF AS PRESSURE IS RELEASED. THIS PROTECTS MOTOR AND KEEPS DOUGH KNEADING.

**BLADE**  
 FORWARD-ON  
 REVERSE  
 OFF

**VITAMIX-MIX**  
**3600**  
 HEAVY DUTY "INSTANT BLADE REVERSAL" U.S. PAT. 3,388,800"  
 STAINLESS STEEL

FORWARD  
 REVERSE  
 PULSE  
 OFF

**The blender is faster than the microwave.**