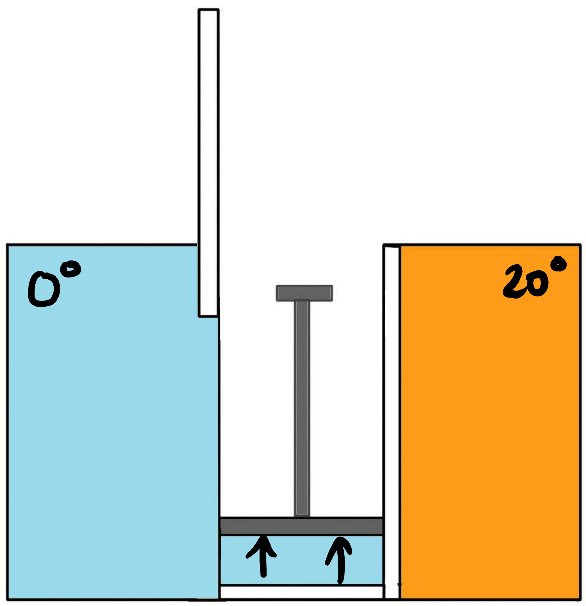
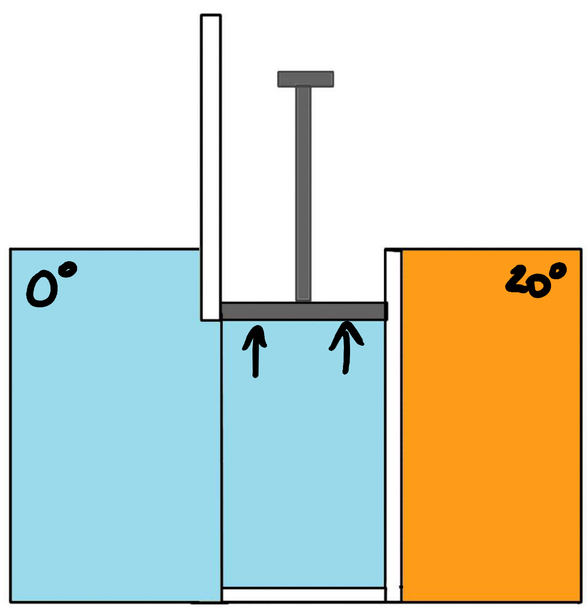


In the process shown, 1 mole gas expands from 5L to 20L while in thermal contact with the system on the left, so that its temperature remains at 0 degrees.

We can say that during the expansion:

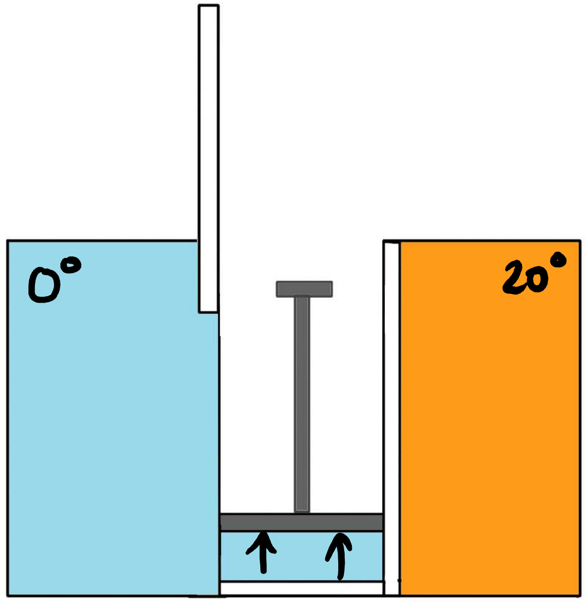
A) Heat flows into the piston from the system on the left.

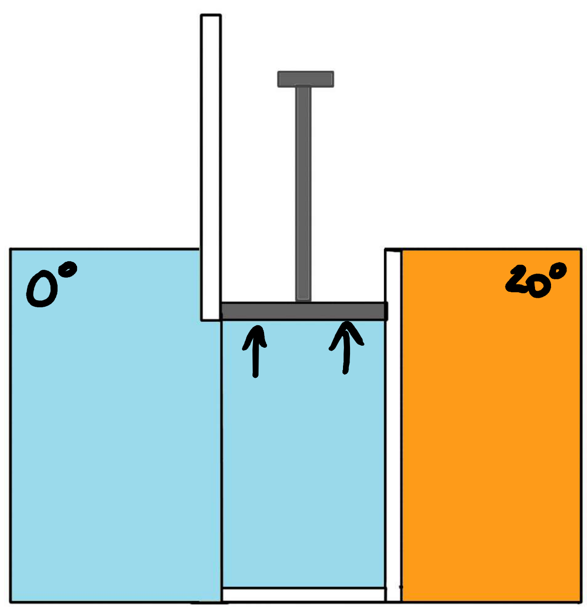


B) Heat flows out of the piston from the system on the left

C) There is no heat flow.

EXTRA: If heat flows, calculate how much.





In the process shown, 1 mole gas expands from 5L to 20L while in thermal contact with the system on the left, so that its temperature remains at 0 degrees.

We can say that during the expansion:

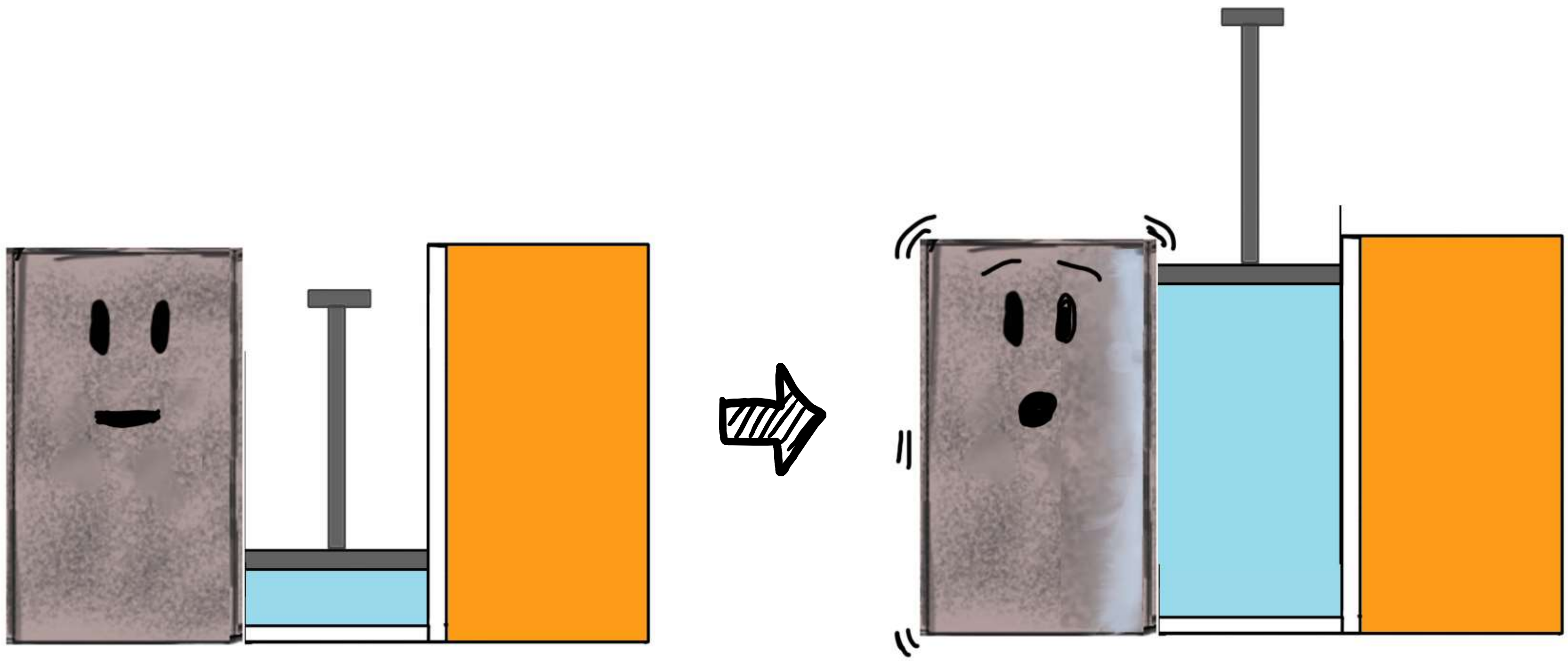
A) Heat flows into the piston from the system on the left.

Const. $T \Rightarrow \Delta U = 0$

First Law: $\Delta U = Q - W$ so $Q = W > 0$
since gas is expanding.

Quantitatively, $W = nRT \ln\left(\frac{V_f}{V_i}\right)$
$= 1 \cdot 8.31 \cdot 273 \cdot \ln(4)$
$= 3145\,J$

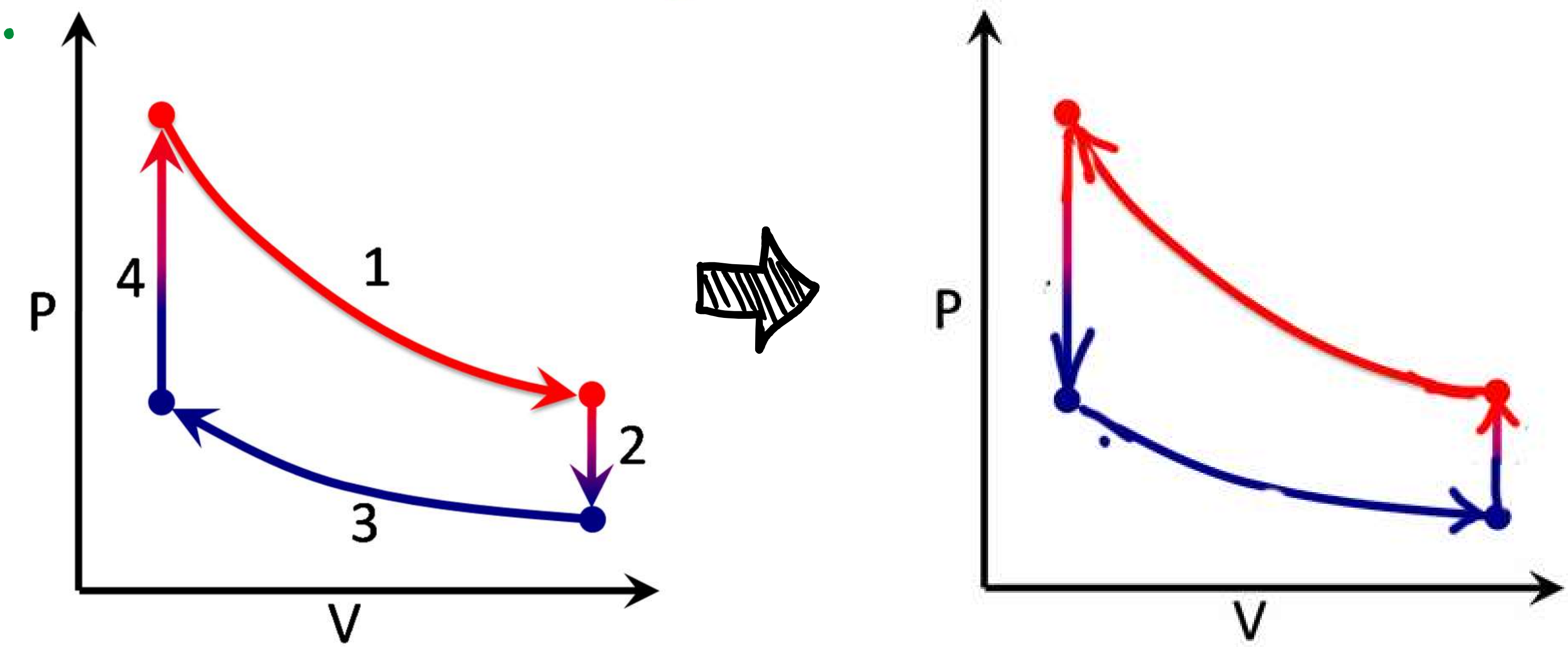
Last time in Phys 157...

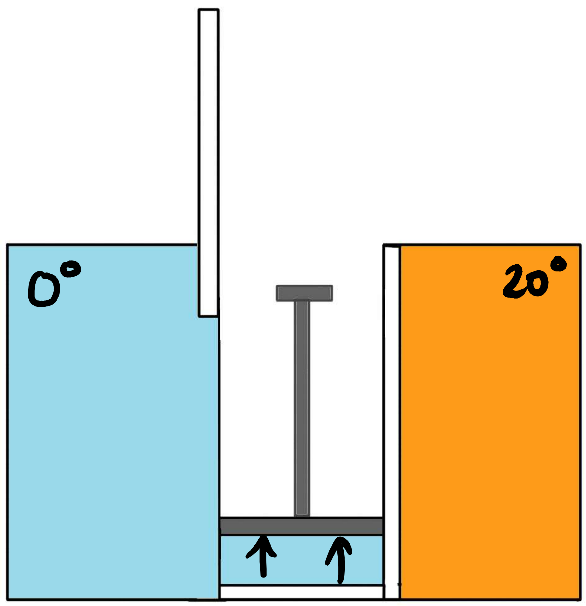


REFRIGERATORS: Can transfer heat from colder system to warmer system by doing work.

☆ Heat engine in reverse ☆

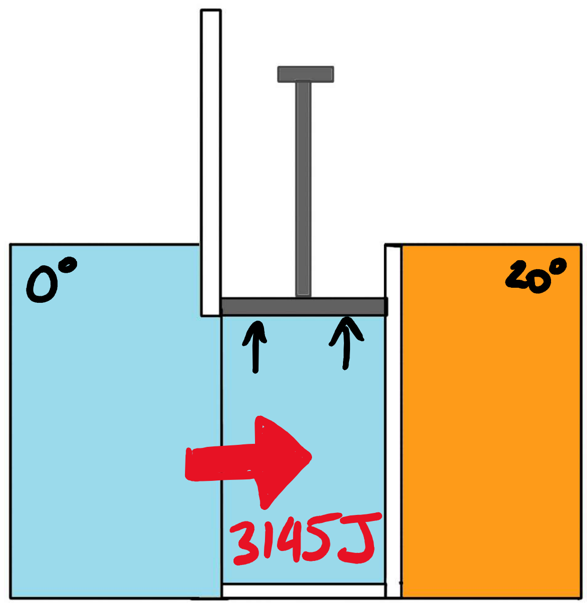
e.g.

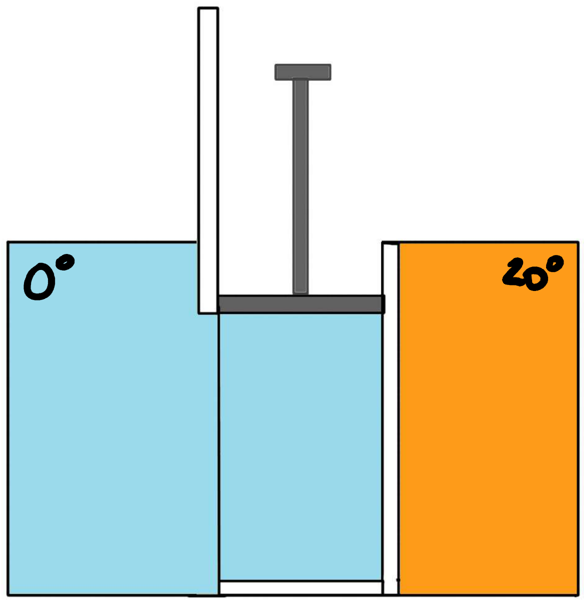




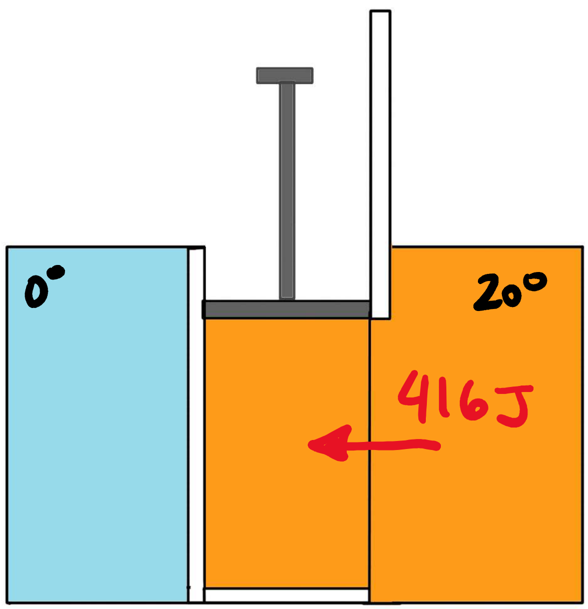
Constant temperature expansion

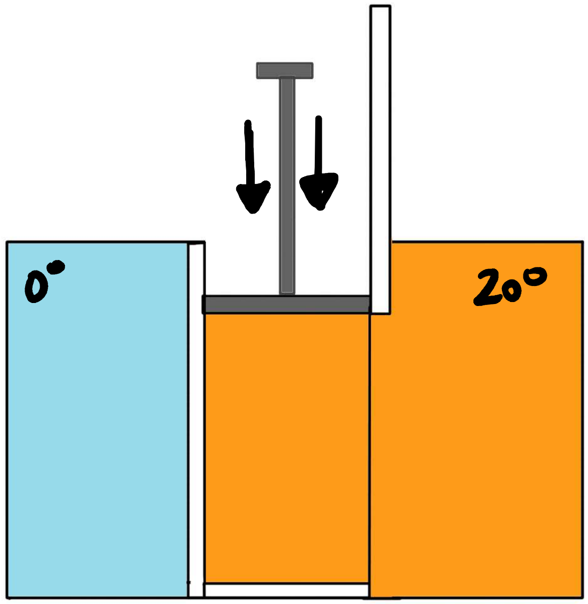
(1 mole, 5L → 20L)



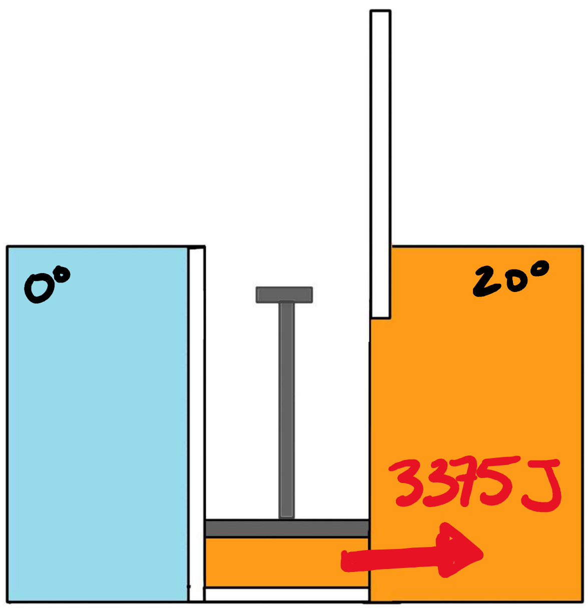


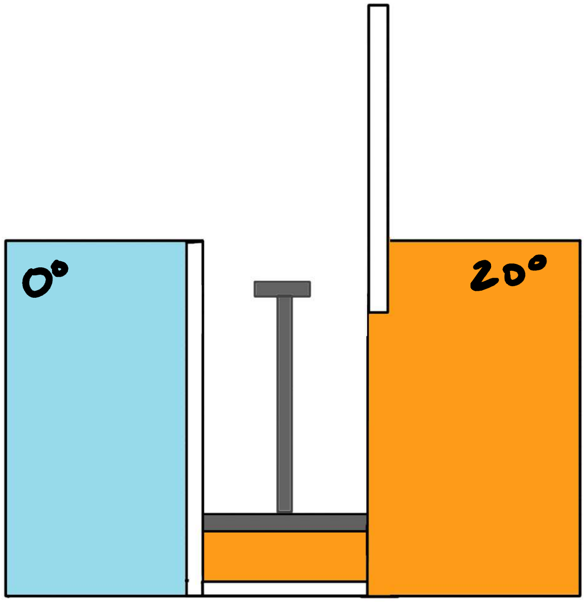
Constant volume heating



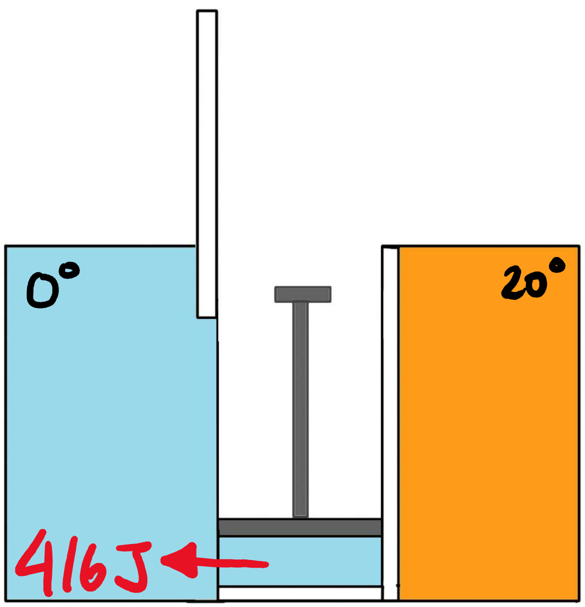


Constant temperature compression

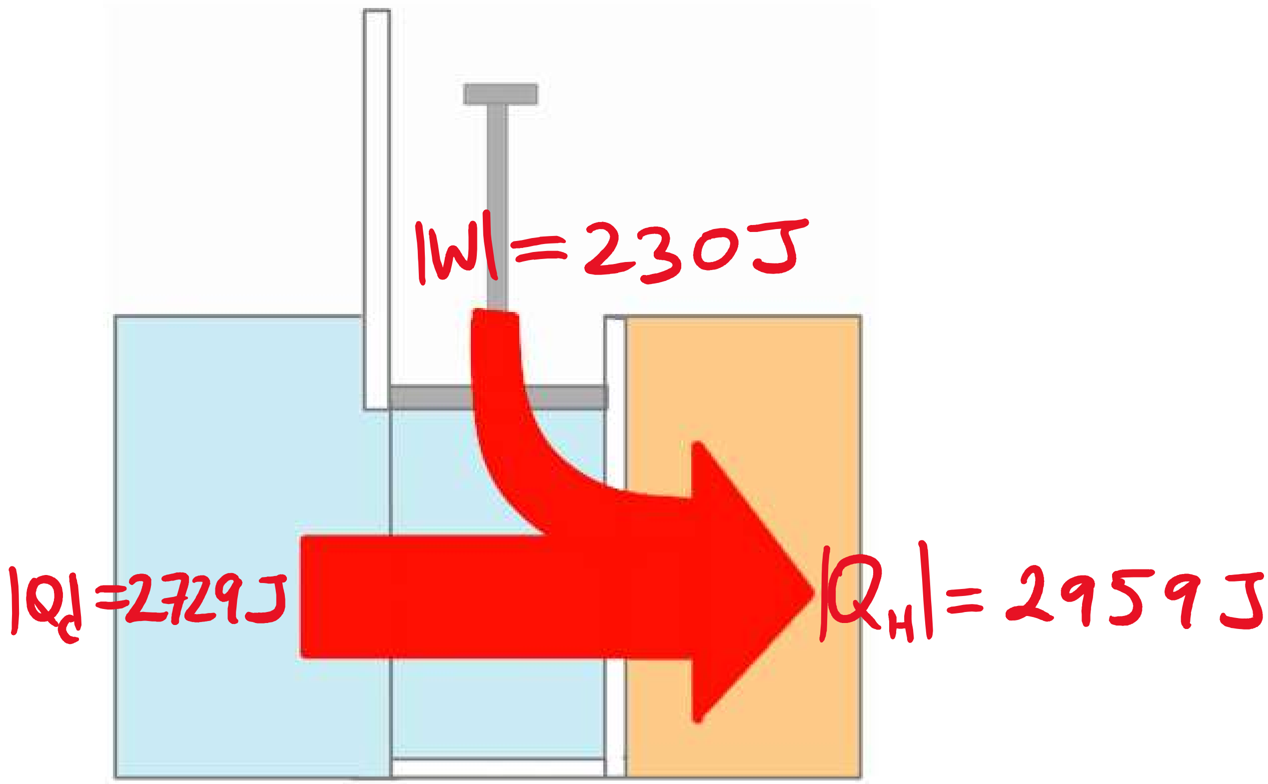




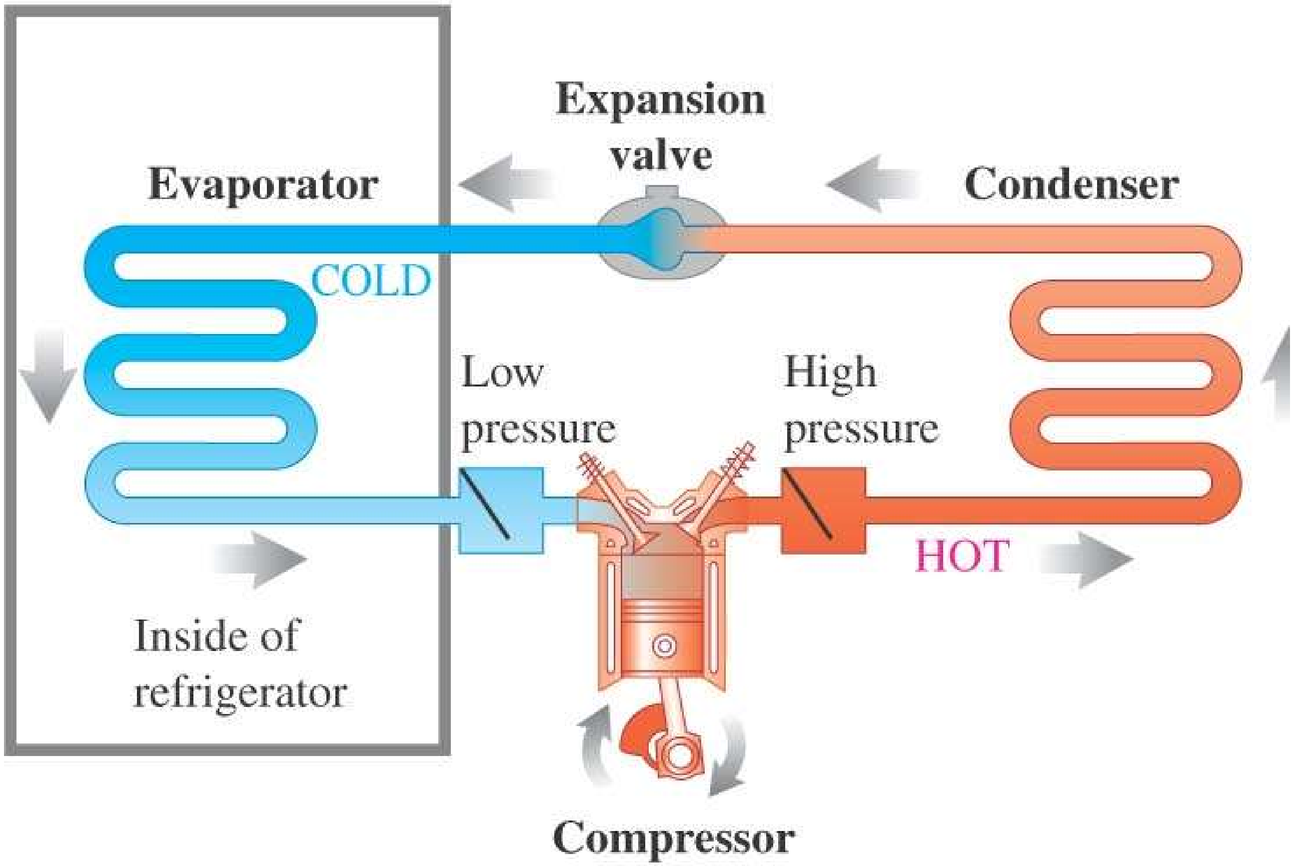
Constant volume
cooling



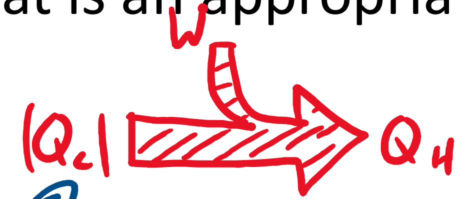
Net result of cycle:



(a) Typical home refrigerator:



It's a hot day and your house doesn't have air conditioning. Your friend Sam suggests leaving the refrigerator door open in order to cool down the kitchen. What is an appropriate response here?



expelled heat = heat taken + work done

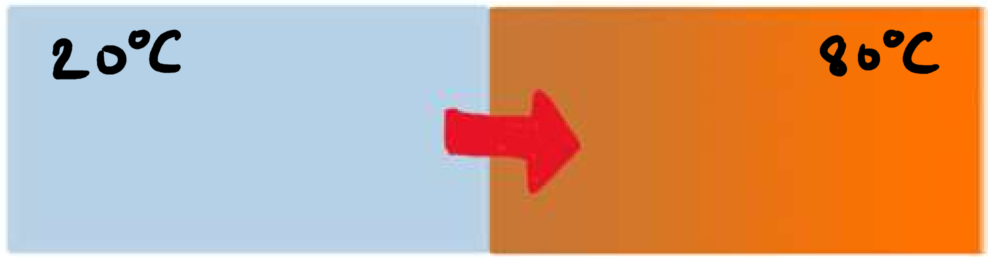
- energy to do work comes from power we supply
- overall, we're converting electrical energy to heat.
- compressor runs more often when door is open.

A) That's a great idea, let's do it!

B) Yes it will cool down the kitchen, but it's a total waste of energy.

C) That won't have any effect at all on the temperature of the room, but the food will go bad.

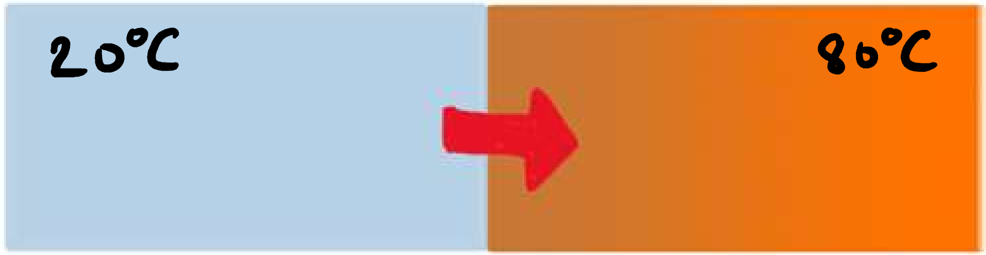
D) Hey Sam, that's great that you're thinking creatively, but it will actually make the room warmer than leaving the fridge door closed.



A flow of heat from a cold object to a hot object (without any associated work) would violate conservation of energy.

A) True

B) False



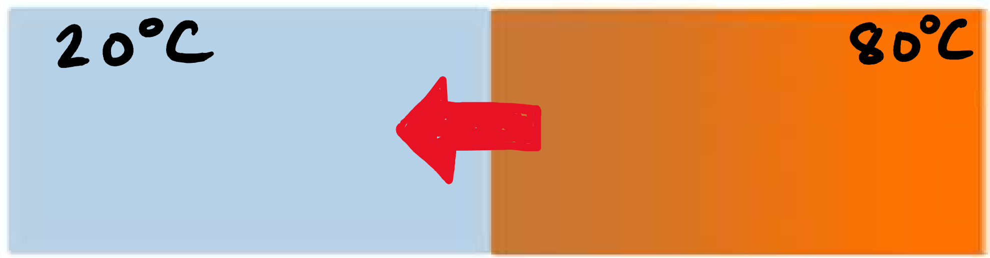
A flow of heat from a cold object to a hot object (without any associated work) would violate conservation of energy.

A) True

B) False

If we moved 100 J from the cold object to the hot object, total energy would be conserved. The cold object would get colder + the hot object would get hotter.

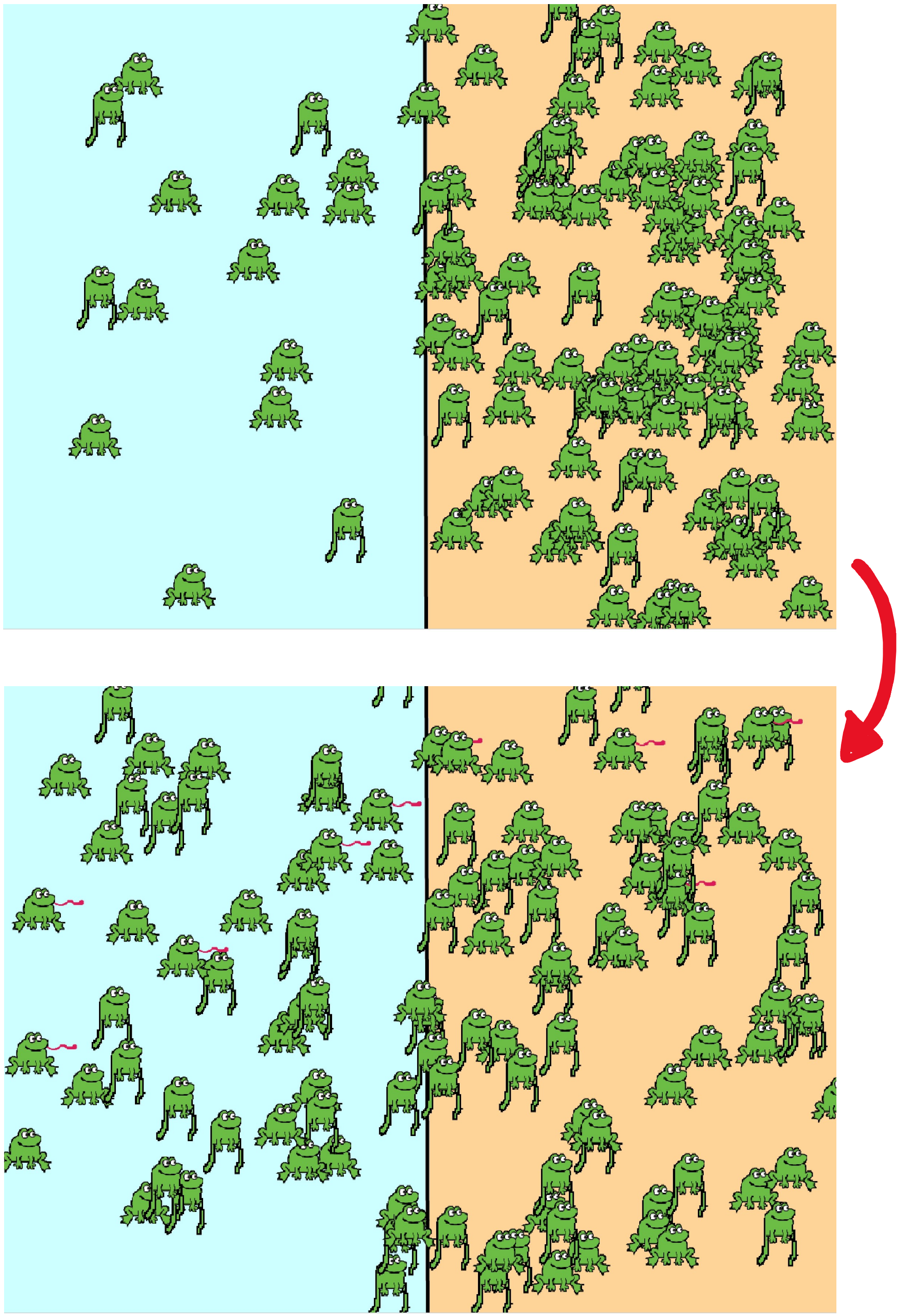
BUT this never happens spontaneously



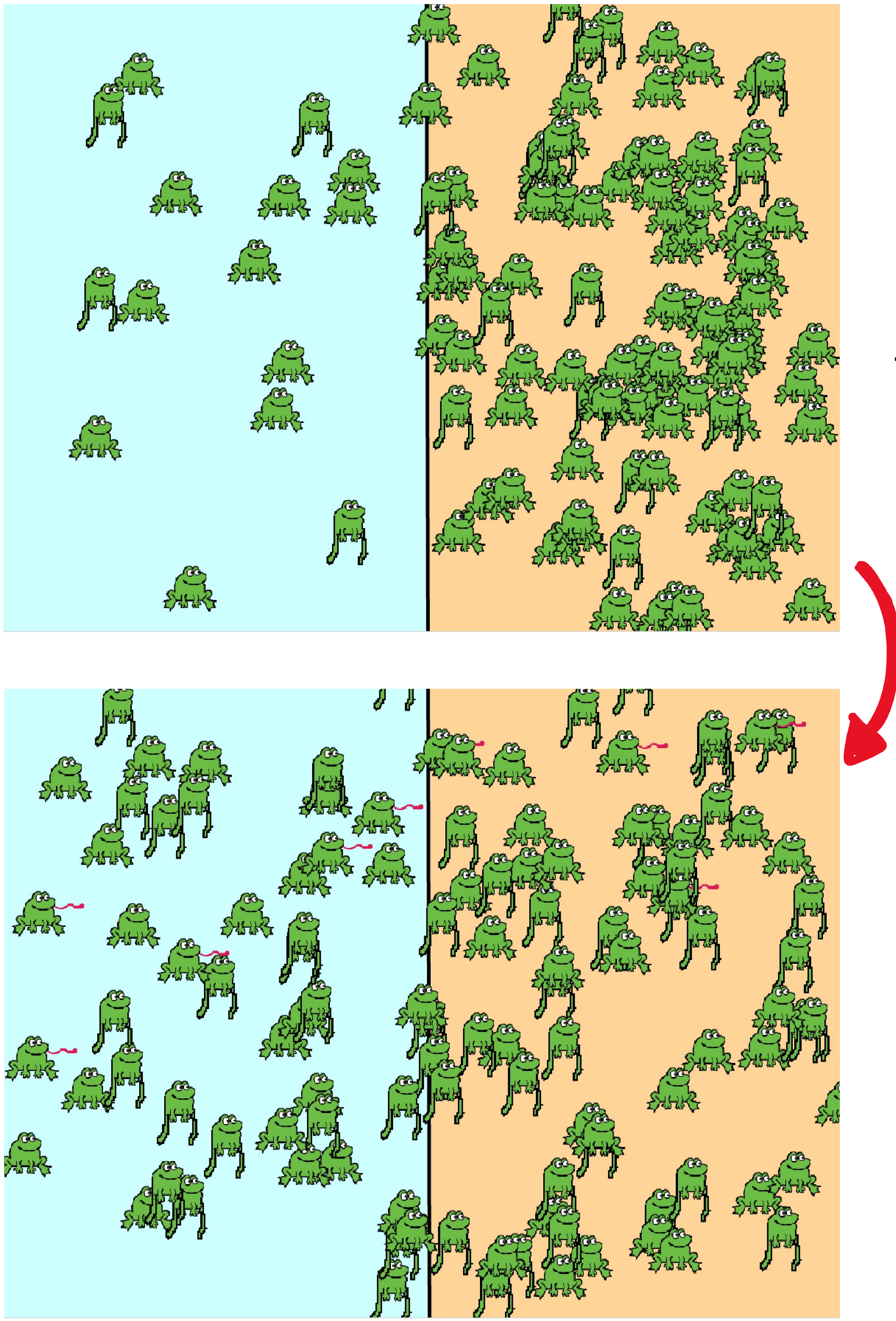
Discussion Question:

Why does heat always flow from hot objects to colder objects?

Let's use an analogy:



If the frogs move around randomly, why is there always a net movement of frogs from an area of high average frog density to an area of low average frog density?



If the frogs move around randomly, why is there always a net movement of frogs from an area of high average frog density to an area of low average frog density?

all configurations of frogs are possible

vastly more configurations with a more balanced number of frogs

almost certain end up with a more balanced number than a less balanced number

In the analogy with a thermodynamic system, the individual frogs represent

A) Molecules

B) Units of energy

C) Temperature

In the analogy with a thermodynamic system, the individual frogs represent

A) Molecules

B) Units of energy

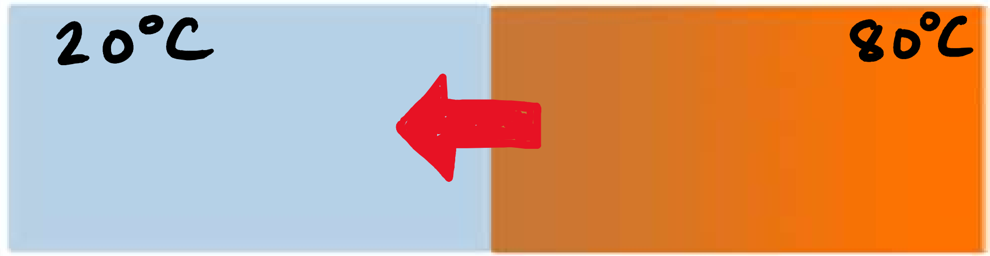
C) Temperature

Frogs $\longleftrightarrow$ energy

(both are conserved & move around the system randomly)

Density of frogs is analogous to temperature.

energy
~ total
# frogs



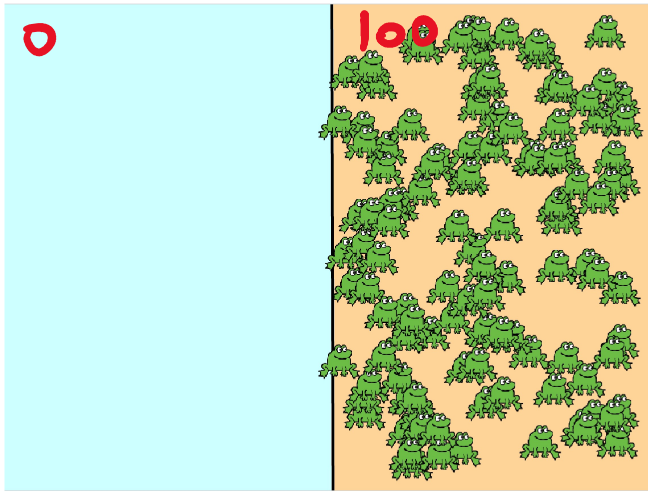
temperature
~ density of
frogs.

* Energy is exchanged between nearby molecules via random processes (like hopping frog) *

* vastly more configurations where energy is distributed more evenly between 2 sides *

* heat will almost certainly flow from higher temp. side to lower temp. side *

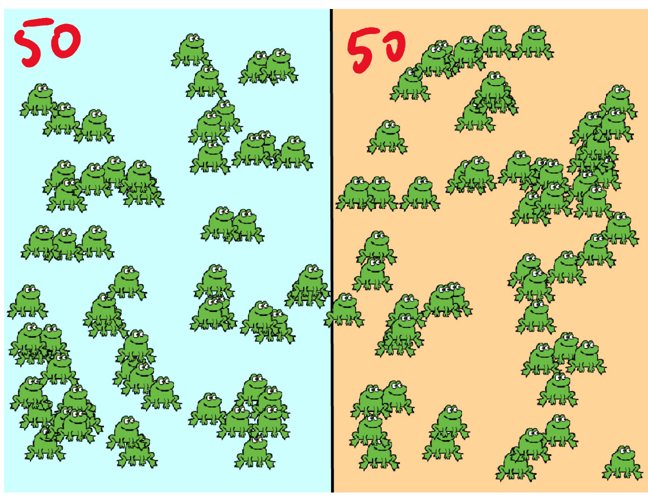
Quantitatively:



frog distribution : (0, 100)

$\sim 10^{500}$ such configurations

(10^5 possible pixel locations for each frog)



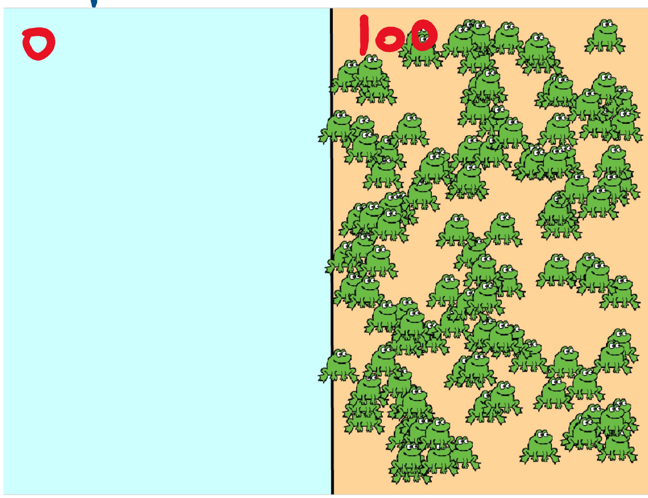
frog distribution: (50, 50)

$\sim 10^{530}$ configurations

after a long time, a (50,50) distribution is
1,000,000,000,000,000,000,000,000,000,000 times more likely

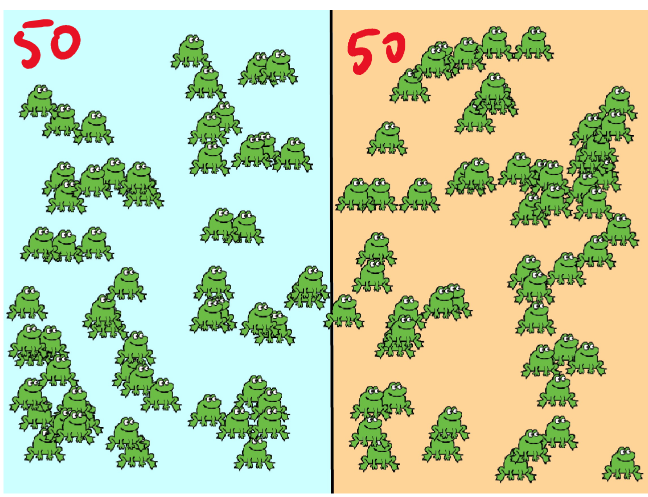
ENTROPY is a measure of how many possible microscopic configurations there are for a specified set of macroscopic variables

e.g:



$\sim 10^{500}$ such configurations

entropy is $\log(N) \sim 500$



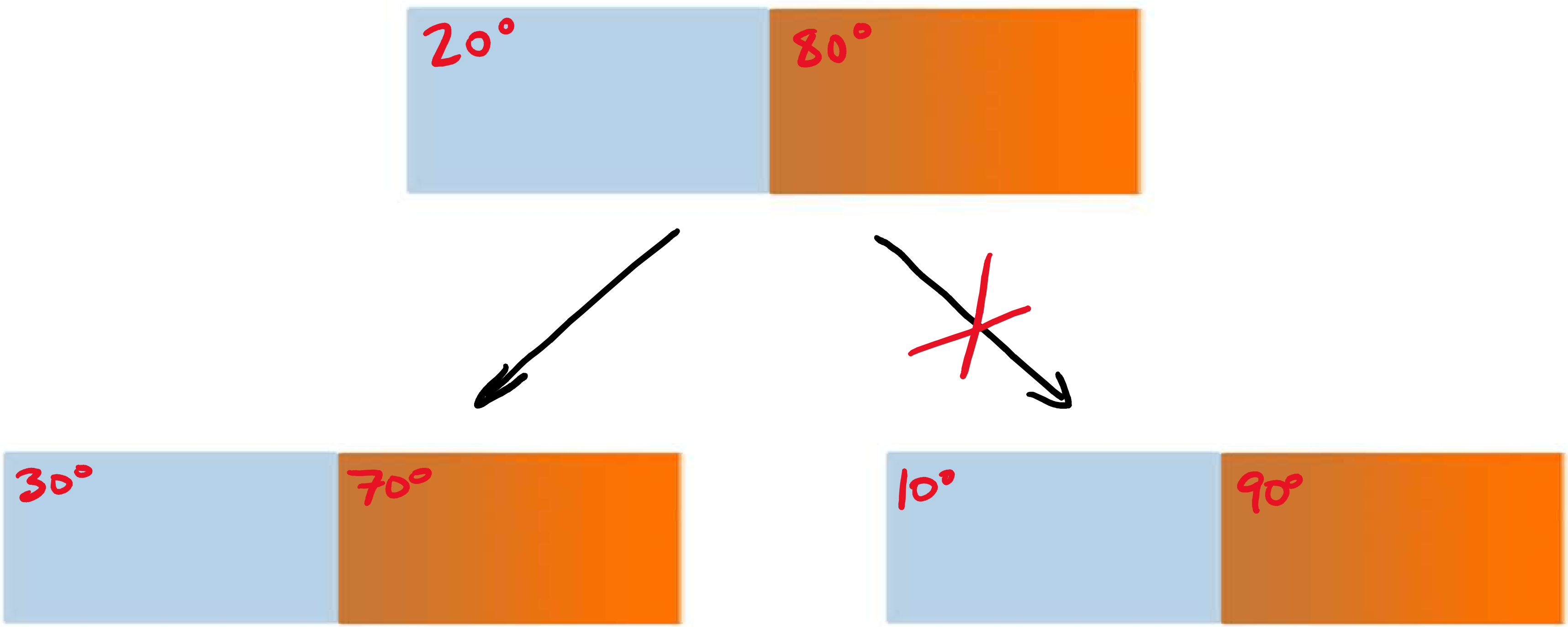
$\sim 10^{530}$ configurations

entropy is $\log(N) \sim 530$

2ND LAW OF THERMODYNAMICS:

Total entropy never decreases.

→ probability of decrease is too small to comprehend



$10^{1\,000\,000\,000\,000\,000\,000\,000}$ times more likely