Introduction to Thermochemistry

Thermochemistry

The study of **ENERGY TRANSFER** in the form of heat during chemical reactions and physical changes.

Deals with:

energy, temperature, heat

- Cannot use those terms interchangeably – they mean different things!
- This chapter can be hard because our real life examples and definitions are not always scientifically accurate

What is energy?

The ability to do **WORK** (Work requires a displacement in position – something has to MOVE)

Potential Energy:

Stored energy DUE TO position or *composition*

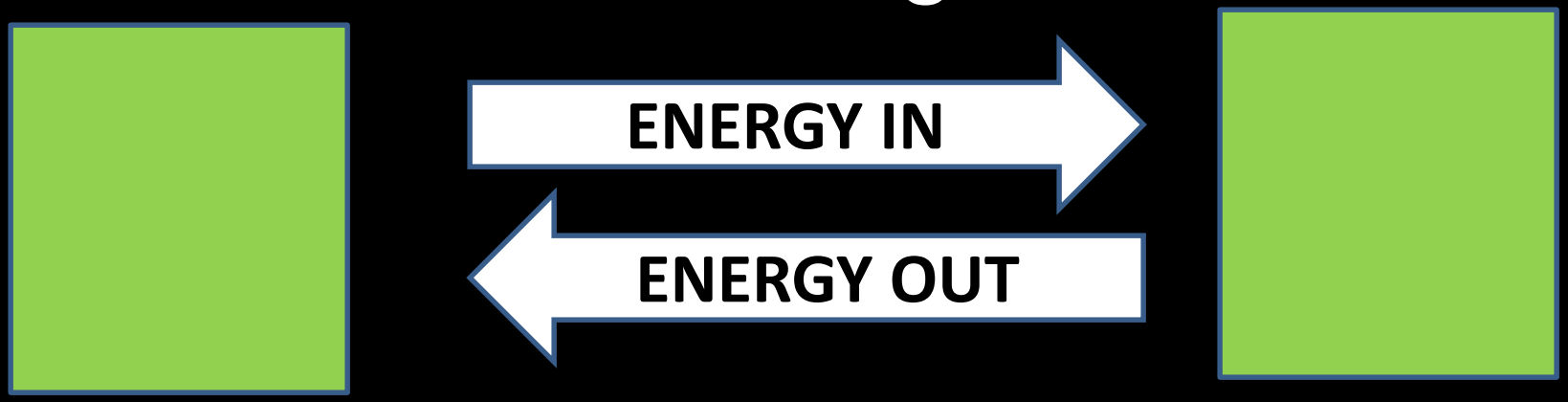
Kinetic Energy:

Energy DUE TO motion

1st Law of Thermodynamics is just like the Law of Conservation of Mass!

You cannot create or destroy energy.

If something loses energy, something else has to gain it!



Law of Conservation of Energy and Law of Conservation of Mass

Energy and Mass are Related!

$E=mc^2$
you can convert between energy and mass!

So if you cant create or destroy matter, then you cant create or destroy energy either!

Temperature vs. Heat

Temperature:

A measure of molecular movement

Deals with: only movement

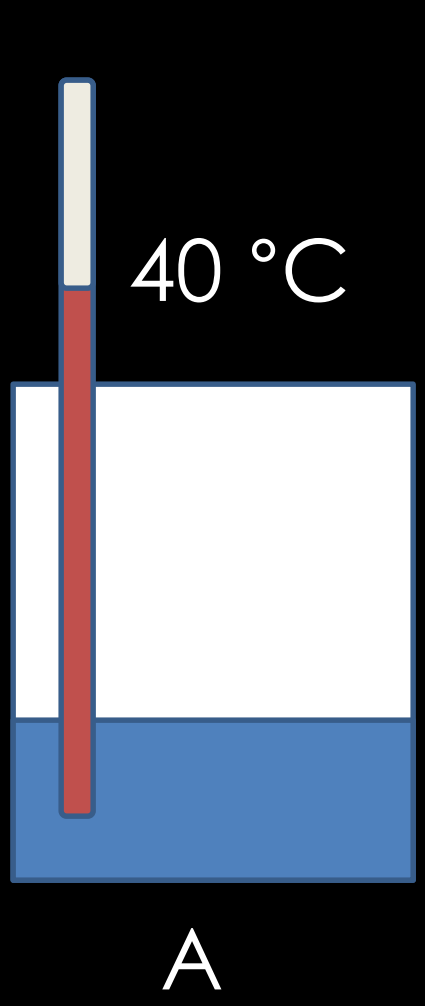
Heat:

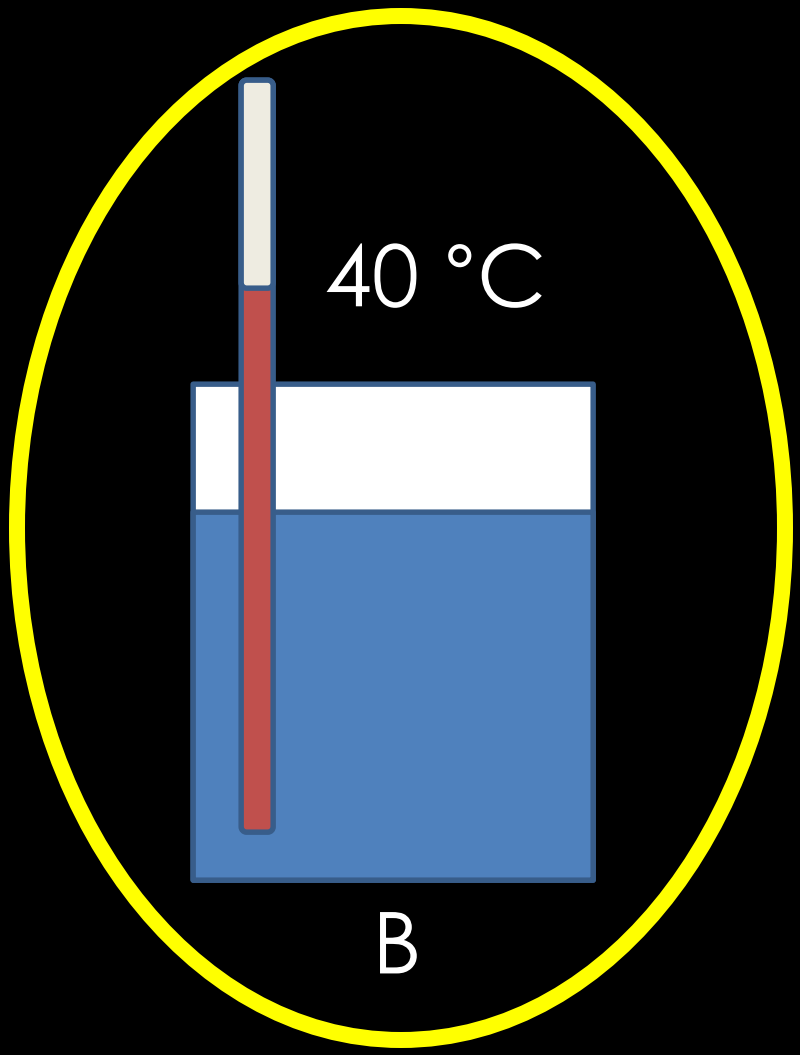
Energy that can be transferred due to the molecular movement.

Deals with: movement AND the <u>amount</u> and type of molecules

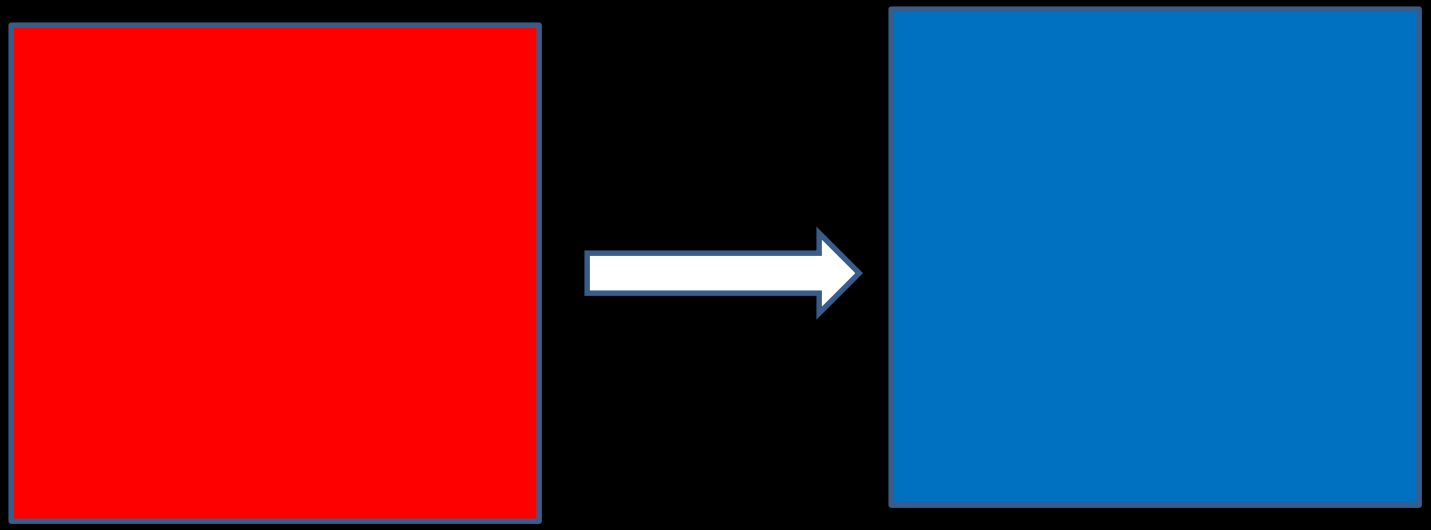
- Which would hurt more? A tablespoon of boiling water poured on you, or an entire pot of boiling water poured on you?
  - The POT of water!
  - They are both at the same temperature, 100C
    - But there are more water molecules in the pot of water, so there is more heat
      - More molecules can do more “work” with that heat energy

Which has more heat?





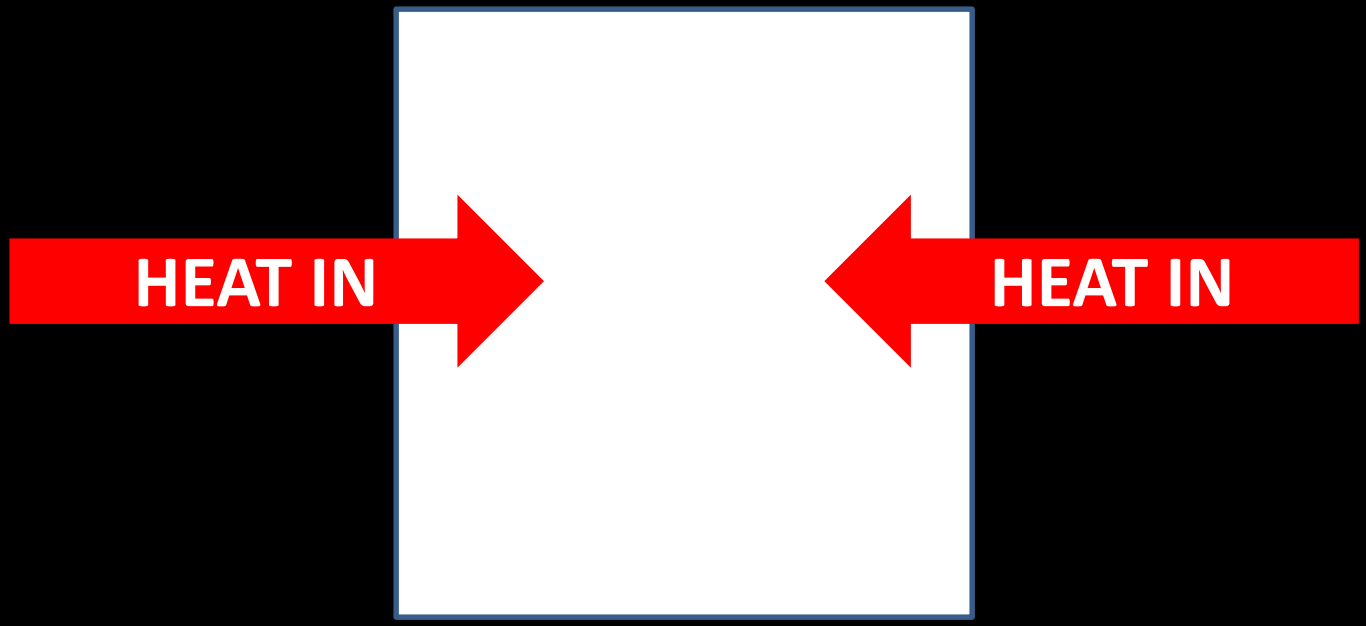
Which way does heat flow?



- It sounds so strange, but we always want to talk about heat moving in the direction of what is warming up. Even though we know the other thing will cool down, that isn't the way we need to think about it for this chapter. If you get it backwards then you will get your +/- signs backwards in the math!
- DON'T say "the ice is cooling my drink down"
- DO say "my drink is heating the ice up"

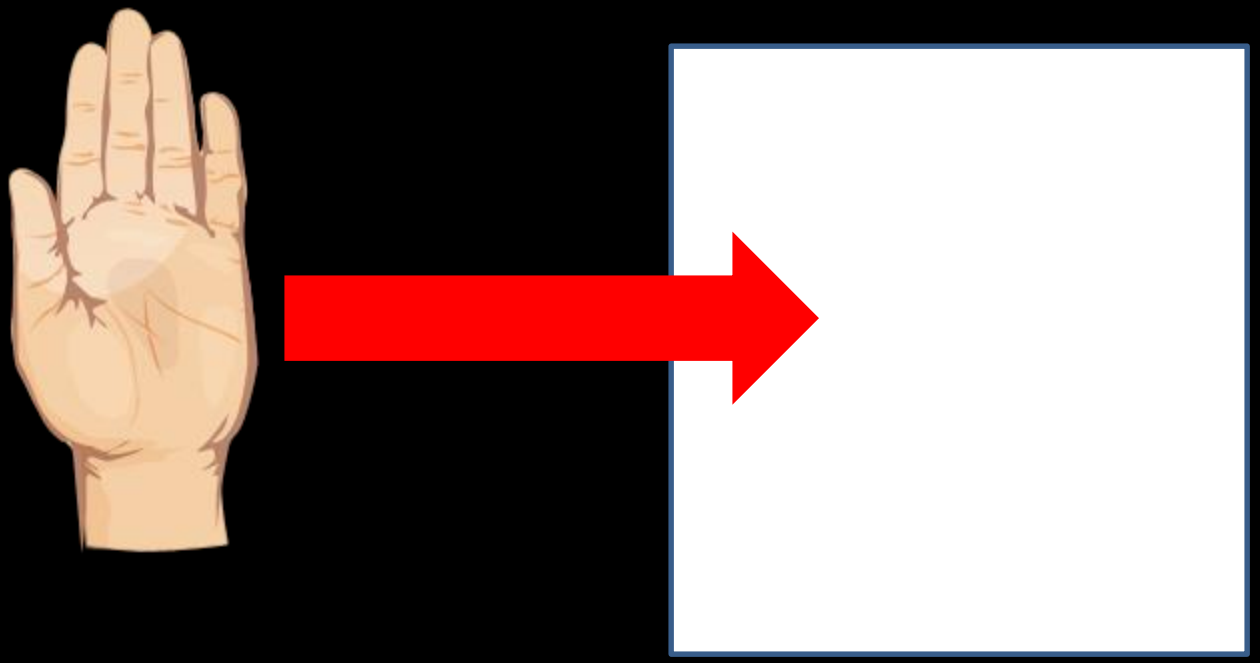
Endothermic

When SYSTEM (reaction) **ABSORBS HEAT**



What do you feel???

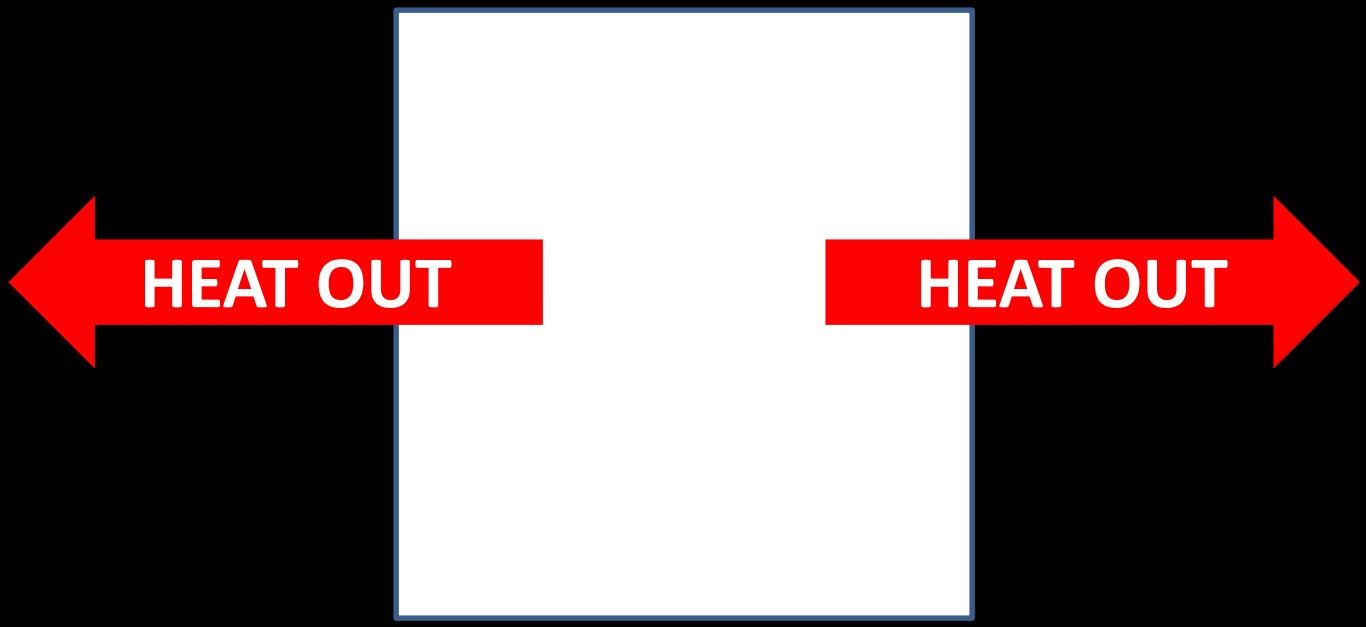
When a SYSTEM (reaction) **ABSORBS HEAT FROM YOU** (you are the surroundings)



YOU FEEL **COLD!!!!!**

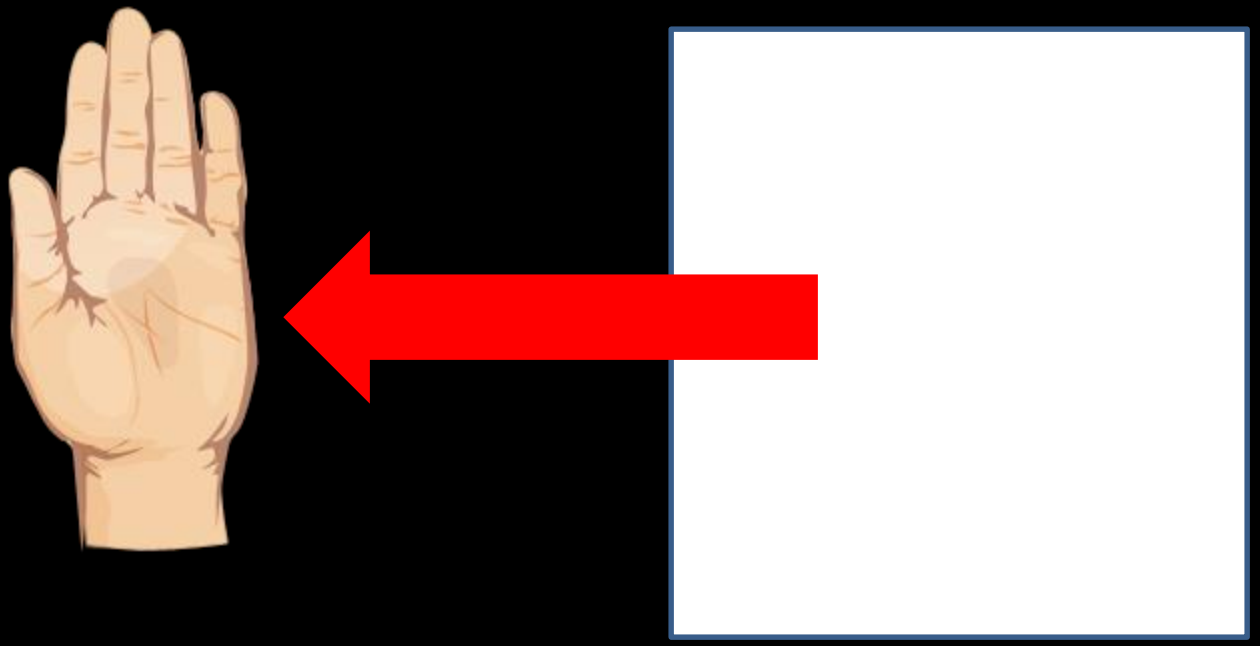
Exothermic

When a SYSTEM (reaction) **RELEASES HEAT**



What do you feel???

When a SYSTEM (reaction) **RELEASES HEAT**
TOWARDS YOU (you are the surroundings)



YOU FEEL **HOT!!!!!**

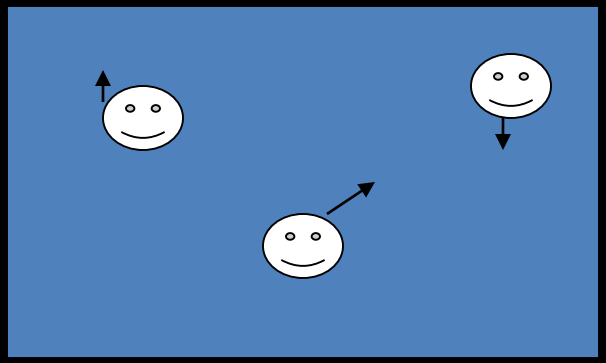
- Can I stick a thermometer INSIDE a chemical bond??? NO!
- I CAN stick a thermometer in the SURROUNDINGS.
  - So for an ENDOTHERMIC reaction, the CHEMICALS (system) are absorbing energy…but the thermometer will show getting colder because the thermometer is in the SURROUNDINGS and the surroundings are losing energy to the system
  - For an EXOTHERMIC reaction, the CHEMICALS (system) are losing energy…but the thermometer will show getting hotter because the thermometer is in the SURROUNDINGS and the surroundings are gaining that energy that is being released

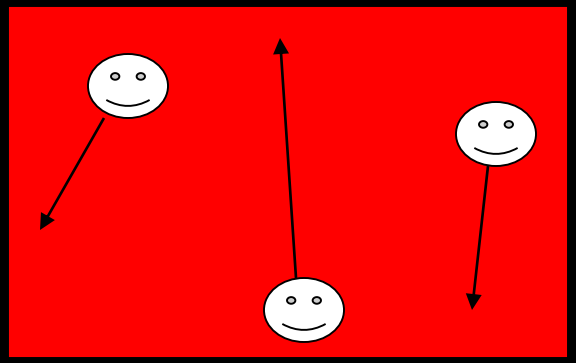
Hot or Cold ALL depends on PERSPECTIVE!!!

Yours or the reactions?

Temperature

- **Average** amount of energy in motion
  - Measured with a thermometer





more motion → Hotter → higher temp

less motion → Colder → lower temp

Which unit for temperature?

Fahrenheit

Too annoying to use! Forget about it!

Celsius

Usually used in science class.

Easy to remember freezing and boiling point.

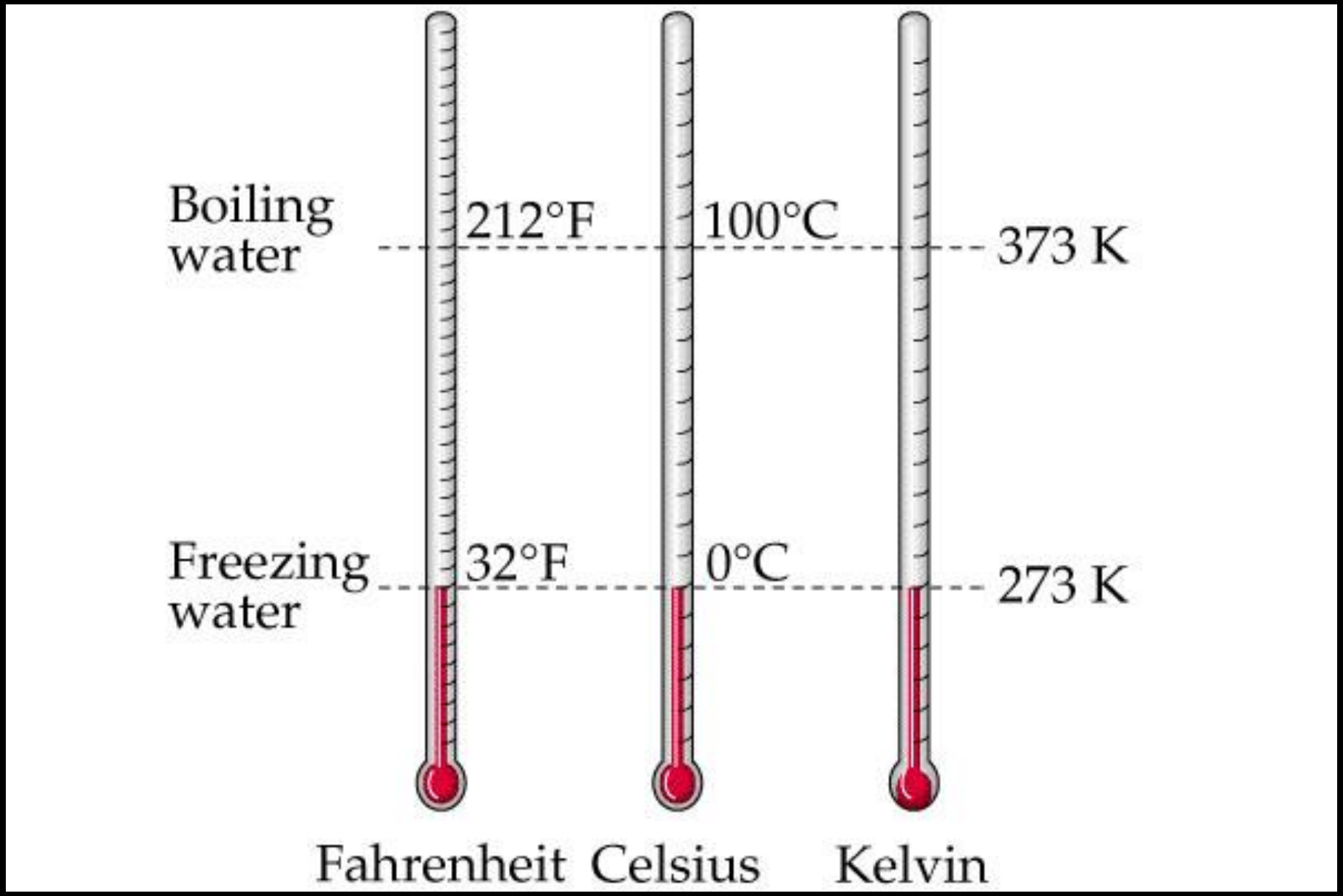
Kelvin

An “absolute” temperature scale.

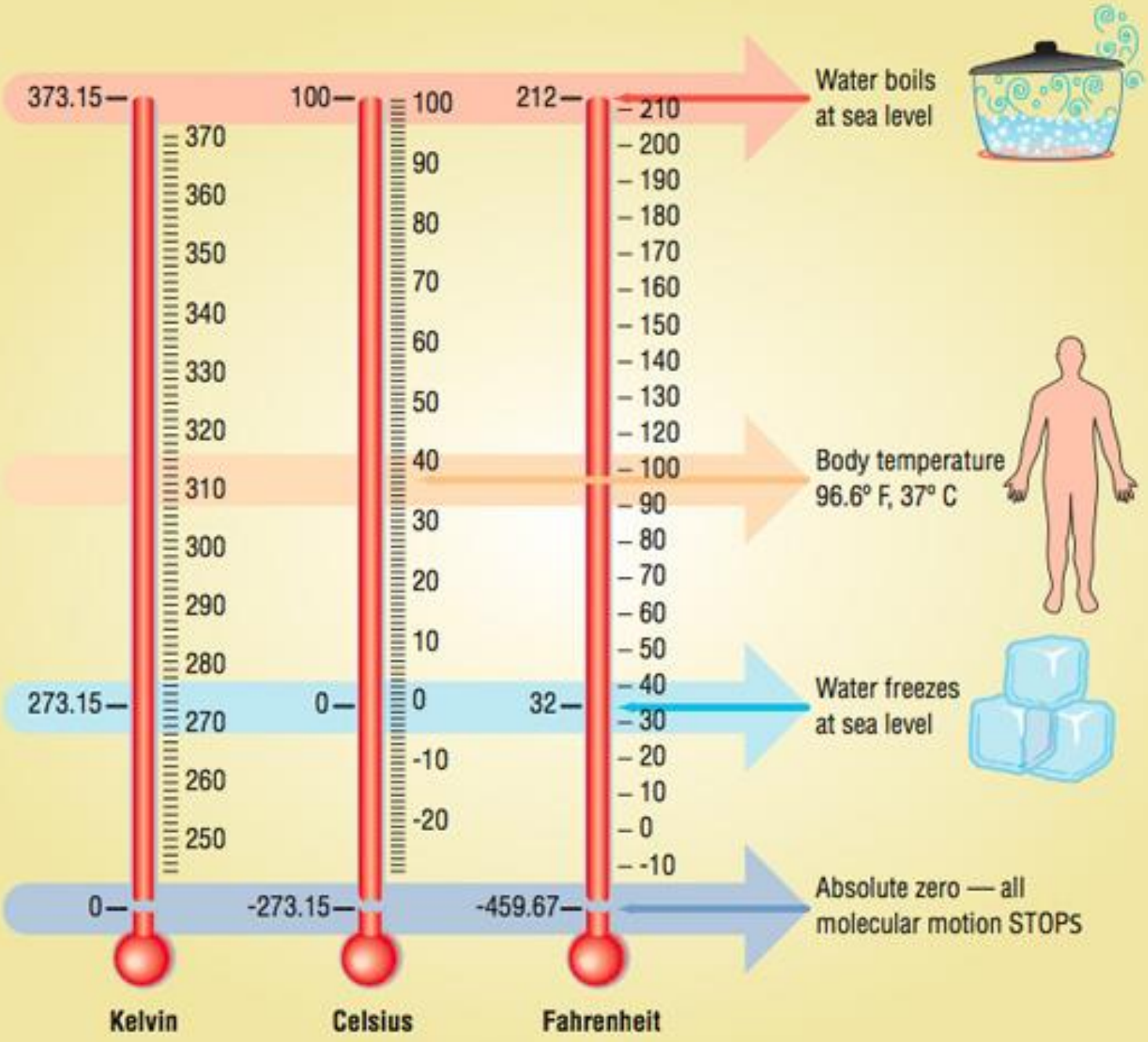
0 K means NO molecular motion!

“Zero means zero!”

Used for some specific calculations


Boiling water
212°F
100°C
373 K
Freezing water
32°F
0°C
273 K
Fahrenheit
Celsius
Kelvin

- Notice how one Fahrenheit degree is a smaller “chunk” then a C or a K degree. Each C and K degree are the same size “chunk.” All we did was slide the thermometer down until zero means zero for Kelvin


373.15
100
212
Water boils at sea level
370
360
350
340
330
320
310
300
290
280
273.15
270
260
250
0
100
90
80
70
60
50
40
30
20
10
0
-10
-20
-273.15
210
200
190
180
170
160
150
140
130
120
100
90
80
70
60
50
40
30
20
10
0
-10
-459.67
Body temperature 96.6° F, 37° C
Water freezes at sea level
Absolute zero — all molecular motion STOPS
Kelvin
Celsius
Fahrenheit

- Notice how F and C both end up having NEGATIVE temperatures?
  - That is a mathematical problem sometimes!
  - If your math is trying to measure the amount of motion of molecules, how can you end up with negative motion?! You cant!
    - That is why some branches of chemistry need to use Kelvin so they never end up with negative numbers!

Converting between C and K

$K = °C + 273$

$°C = K - 273$

- Actually 273.15 BUT we use 273
  - Our thermometers aren't that good in high school science class!
- We have never reached absolute zero! We have gotten close but not all the way
  - 0.0005 Kelvins is the coldest we have been able to do.