Big Picture Podcast – Episode 17

The Chemistry of Water, Part 2 (Chapter 8C)

Do-The-Review

Co-hosts John Suchocki and Marjorie Suchocki review the second half of the Conceptual Chemistry chapter on the properties of water. Topics include evaporation, boiling, pressure cookers, hurricanes, specific heat, global warming, and the heat of vaporization. We review all these topics from the molecular point of view. Duration: 42:57.

Our apologies for the poor quality of this transcript. We are currently looking into how to solve this issue.

John: Welcome to part two of our discussion on the properties of water with cohosts John Suchocki and Marjorie Suchocki. We pick up where we left off from the previous episode. Welcome back. All right, now we've talked about water from the solid phase.

Marjorie: Yeah.

John: Then

Marjorie: Then

John: We

Marjorie: We went.

John: Went to the liquid phase and we

Marjorie: Yeah,

John: Talked about

Marjorie: About.

John: Going from solid to liquid and liquid to solid.

Marjorie: Pollard Yes.

John: And then we talked about properties of the liquid itself. The surface tension in capillary action or the two we talked about. Next, we're going to talk about the gaseous phase,

Marjorie: Yeah,

John: Right?

Marjorie: Right, yeah.

John: Water

Marjorie: Water

John: Molecules

Marjorie: Molecules

John: Going

Marjorie: Going

John: From

Marjorie: From

John: The liquid

Marjorie: Liquid rays

John: Phase to

Marjorie: To

John: The

Marjorie: The

John: Gaseous

Marjorie: Gas.

John: Phase.

Marjorie: Yeah.

John: At the surface, you'll find water molecules escaping from the liquid phase, transforming into a gaseous phase. Now, you'll recall and gashes face water molecules relatively far apart from each other and they're not sticking to each other

Marjorie: Oh.

John: At all. And they occupy a lot more volume in the liquid phase. The water molecules are all

Marjorie: Sticky.

John: Together. They take sticky together, tumbling and tumbling over one another

Marjorie: They're

John: Like

Marjorie: Like

John: A

Marjorie: A

John: Bunch

Marjorie: Bunch

John: Of

Marjorie: Of

John: Marbles

Marjorie: Marbles.

John: In a bag. So here's what happens when you have a puddle of water. You're ready. Imagine a puddle water on a summer day. You are going to have some of those water molecules escaping from the liquid phase into the air.

Marjorie: They

John: They do?

Marjorie: Do.

John: Yeah. And that's how you'll note how the puddle eventually disappears

Marjorie: Does it make humidity?

John: And it makes the air more humid

Marjorie: Oh.

John: Near the water in the liquid phase. You're going to have water molecules that can't escape to gaseous face.

Marjorie: Oh, well, that's interesting.

John: Now,

Marjorie: Now, here's

John: Here's my

Marjorie: My

John: Question

Marjorie: Question

John: For

Marjorie: For

John: You.

Marjorie: You.

John: You

Marjorie: You

John: Ready

Marjorie: Ready? OK.

John: Of all those water molecules in the liquid phase? Which ones are the ones most likely to escape into the gaseous phase?

Marjorie: Well, I would think it would be the ones on the surface,

John: Ok.

Marjorie: Like

John: The

Marjorie: The

John: Ones

Marjorie: Ones on

John: On

Marjorie: The

John: The surface.

Marjorie: Right is probably wrong.

John: No,

Marjorie: No,

John: No. That's

Marjorie: That's it.

John: It. Get the

Marjorie: Ok.

John: One. You

Marjorie: You

John: Got

Marjorie: Got to

John: To be

Marjorie: Be

John: The

Marjorie: The surface.

John: Surface. What's another when we talk about which molecules are going to do this?

Marjorie: Leaming Which molecules?

John: Do you imagine all the molecules are moving at the same speed?

Marjorie: Well, they are tumbling over each other

John: Yeah,

Marjorie: Like marbles.

John: They are. But get this. Here's some new information for you.

Marjorie: Okay.

John: Some are tumbling faster than others. Not all water molecules are moving at the same speed.

Marjorie: Why not?

John: There's a distribution.

Marjorie: Is the distribution based on the temperature or something else?

John: The higher the temperature, the higher the average speed.

Marjorie: It's.

John: So when we talk about temperature, it's the average speed of your molecules. Some are moving really fast. Some

Marjorie: Some.

John: A move, a really slow. Most of them are moving about like this. And you have a Gaussian curve distribution. Some are moving fast. Some are moving slow. Some are moving just like this. The average is the speed at which most of them are moving. You will find within that puddle of water.

Marjorie: Or

John: Some

Marjorie: Some.

John: Water molecules that actually are moving way fast

Marjorie: Those were

John: Ones.

Marjorie: The ones who would escape.

John: You've got to be at the surface and you got to be moving really fast. Those water molecules are the ones with the greatest tendency to even evap evaporate,

Marjorie: That 4 8.

John: Evaporate. Evaporation is the process of going from a liquid phase to the gaseous phase.

Marjorie: How interesting. I didn't know that some of its molecules would be going faster than

John: Yeah.

Marjorie: Others.

John: Is

Marjorie: That's

John: That it?

Marjorie: Interesting

John: Yeah. New information.

Marjorie: Reason. Yeah.

John: All right, so

Marjorie: So.

John: Look what you're doing now. During that evaporation process,

Marjorie: Susan, you.

John: You are removing all the fast moving water molecules.

Marjorie: Oh.

John: What happens to the average temperature of the liquid that's left behind?

Marjorie: I would think it would get.

John: The average speed you remove all the fast moving ones.

Marjorie: Yeah, I've been usually get the slow ones, but they might begin to move a little faster

John: No,

Marjorie: With the others

John: No,

Marjorie: Gone.

John: Unless they wouldn't, unless there's a source of energy.

Marjorie: Well, there's all that heat coming down from the sun.

John: Well,

Marjorie: Well, let's

John: Let's ignore

Marjorie: Ignore

John: The

Marjorie: The sign

John: Sun. You just have

Marjorie: Of

John: A

Marjorie: A puddle

John: Puddle of

Marjorie: Of

John: Water.

Marjorie: Water. Yes, it's

John: It's cloudy

Marjorie: Cloudy day.

John: Today

Marjorie: Yes.

John: Because it's humid out, right. And

Marjorie: And

John: The

Marjorie: The

John: Water

Marjorie: Water

John: Molecules

Marjorie: Molecules

John: Are

Marjorie: Are.

John: Evaporating. Going from the

Marjorie: Yeah.

John: Liquid

Marjorie: Liquid

John: Phase

Marjorie: Phase

John: To

Marjorie: To

John: The

Marjorie: The

John: Gashes

Marjorie: Gas. Yes.

John: Phase. And we're pointing out which water molecules exactly are the ones to do

Marjorie: Do

John: That.

Marjorie: That and the

John: The

Marjorie: Fast

John: First

Marjorie: Went and it leaves

John: One

Marjorie: The slow ones

John: It

Marjorie: It

John: Leaves

Marjorie: Leaves.

John: The ones bind.

Marjorie: But right

John: Now,

Marjorie: Now,

John: Temperature

Marjorie: Temperature.

John: Is a measure of the average speed of your molecules.

Marjorie: Oh, really?

John: Well,

Marjorie: Well, then

John: Then

Marjorie: The it

John: What happens

Marjorie: Gets cooler.

John: To the X

Marjorie: It's

John: Cooler?

Marjorie: Cooler.

John: So that's how it is. Evaporation is a cooling process.

Marjorie: Oh, yes.

John: Yes.

Marjorie: Well, that's funny.

John: And that's when we sweat.

Marjorie: Yeah.

John: The sweat is evaporating from her skin. They are the fast moving molecules that leave us,

Marjorie: But

John: Elsa.

Marjorie: Elsa Pants, that gets

John: The

Marjorie: The dog.

John: Dog. My sister's dog. Same thing, though. The faster moving molecules are the ones that leave and the average motion of the molecules that remain behind goes down. It's a cooling process.

Marjorie: Ok.

John: So the water that's left behind cools down.

Marjorie: Yeah,

John: You got that

Marjorie: Right.

John: Right. Now

Marjorie: Now

John: Let's

Marjorie: Let's

John: Look

Marjorie: Look

John: At

Marjorie: At.

John: It

Marjorie: But

John: From

Marjorie: If

John: The

Marjorie: It cools

John: Start.

Marjorie: Down,

John: You have less

Marjorie: It shrinks.

John: Of it's. Yeah,

Marjorie: Yeah.

John: Well

Marjorie: Well you

John: You have

Marjorie: Have less

John: Less

Marjorie: Of.

John: Of it. Don't

Marjorie: Yeah.

John: Worry about

Marjorie: About

John: The

Marjorie: The

John: Density

Marjorie: Dance.

John: At this point

Marjorie: Oh okay.

John: Because.

Marjorie: Because.

John: Because

Marjorie: Because

John: It's

Marjorie: It's lost

John: Lost

Marjorie: All

John: All those

Marjorie: Those

John: Atoms

Marjorie: Atoms

John: Molecules.

Marjorie: Molecules.

John: And

Marjorie: And

John: Since

Marjorie: Since it's

John: It's losses

Marjorie: Lost those

John: Molecules,

Marjorie: Molecules

John: It's

Marjorie: There's

John: Not

Marjorie: Not

John: As

Marjorie: As

John: Much

Marjorie: Much

John: Of

Marjorie: Of

John: It

Marjorie: It as

John: As

Marjorie: There

John: It

Marjorie: Was

John: Was before.

Marjorie: Before.

John: Yeah.

Marjorie: Yeah.

John: It's

Marjorie: It's

John: Colder

Marjorie: Colder

John: But

Marjorie: But you

John: You

Marjorie: Also

John: Also

Marjorie: Have

John: Have less

Marjorie: Less

John: Of it.

Marjorie: Yet.

John: That's true. Right. You understand now how it is that the puddle itself cools down

Marjorie: Oh.

John: Because you're removing all the fast moving molecules.

Marjorie: Oh.

John: Let's look at it from the point of view of the air surrounding that puddle. When that fast moving molecule leaves the water.

Marjorie: Quill's here.

John: How so?

Marjorie: Well, because it's part it's water. It's a mount water molecule and then it is into the air and it it cools it down.

John: Well, here's something perhaps you haven't thought of yet.

Marjorie: Well, here

John: You're

Marjorie: It

John: Ready

Marjorie: Is.

John: When that water molecule, that fast moving water molecule. Breaks through the surface. Can you envision that those water molecules that are at the surface are kind of like yanking on its leg saying, hey, don't leave here?

Marjorie: All of the ones on the surface wanted just don't

John: Wanted

Marjorie: Wanted to believe.

John: Don't wanted to leave there surfaced.

Marjorie: Serious attention?

John: Tension. Yes,

Marjorie: Yes.

John: Surface tension. That water molecule has to break through that surface tension. That water molecule has to escape

Marjorie: Well,

John: The cooling

Marjorie: Leave.

John: Of all those remaining water molecules.

Marjorie: Well, how can I do that?

John: It requires energy to

Marjorie: Louisville.

John: Pull water molecules away from

Marjorie: Does

John: Each

Marjorie: He

John: Other,

Marjorie: Get

John: Does

Marjorie: It from

John: It not?

Marjorie: The sun?

John: It's member. It's a fast moving molecule,

Marjorie: All right,

John: But

Marjorie: But.

John: After it leaves the surface. Guess what?

Marjorie: Oh,

John: It's

Marjorie: It slows

John: Not.

Marjorie: Down.

John: It's

Marjorie: It's.

John: Slowed down because it lost some of its kinetic energy

Marjorie: It did

John: To overcome

Marjorie: Over time to get

John: Through

Marjorie: Through,

John: To

Marjorie: To

John: Get

Marjorie: Get

John: Through.

Marjorie: Through. Yeah.

John: Yeah.

Marjorie: Yeah.

John: Its

Marjorie: It's a

John: Barrier,

Marjorie: Barrier. Oh, yeah, of

John: Of course.

Marjorie: Course.

John: Yeah. So you're now a slower moving water molecule

Marjorie: Yeah.

John: And that means lower temperature. Yeah.

Marjorie: Yeah,

John: So

Marjorie: So

John: That's

Marjorie: That's

John: How

Marjorie: How

John: It

Marjorie: It

John: Is.

Marjorie: Is,

John: The

Marjorie: The

John: Air

Marjorie: Evaporation

John: Above

Marjorie: Cools it.

John: Evaporation cools no matter how you look at it

Marjorie: Hear

John: From

Marjorie: From

John: The

Marjorie: The

John: Point

Marjorie: Head

John: Of view

Marjorie: Of

John: Of

Marjorie: The.

John: The liquid that remains behind it cools down from the point of view of the air above it. It cools down. There you

Marjorie: No,

John: Go.

Marjorie: It does. And so when you sweat, it cools you down.

John: So why does a canteen often have a cloth around it?

Marjorie: In insulates it fooled

John: You

Marjorie: You.

John: Okay? It does.

Marjorie: What

John: Well,

Marjorie: Happens

John: It's an

Marjorie: In

John: Installation.

Marjorie: Insulation? Why do you

John: No,

Marjorie: Want to

John: No. It's.

Marjorie: Sleep?

John: But

Marjorie: But what

John: What about

Marjorie: About if

John: If

Marjorie: You

John: You get

Marjorie: Get

John: That

Marjorie: That?

John: Cloth wet?

Marjorie: If you get the cloth wet, it works even better.

John: Because as the cloth is wet,

Marjorie: It

John: It's

Marjorie: Begins to evaporate,

John: Easy to

Marjorie: And as it

John: Evaporate.

Marjorie: Evaporates,

John: It

Marjorie: It cools

John: Cools

Marjorie: Down.

John: Down

Marjorie: Everything,

John: And the water inside

Marjorie: Including

John: The canteen.

Marjorie: The in

John: The

Marjorie: The metal

John: Medal.

Marjorie: Is

John: Yeah.

Marjorie: Cooled and

John: And

Marjorie: Then

John: Then.

Marjorie: Cooling metal cools the water.

John: Excellent,

Marjorie: Excellent.

John: Excellent.

Marjorie: Next, Mia, so was an easy one.

John: All

Marjorie: All

John: Right,

Marjorie: Right, then.

John: Then next

Marjorie: Next, we

John: We

Marjorie: Can

John: Can move

Marjorie: Move

John: On

Marjorie: To

John: To boiling,

Marjorie: Boiling.

John: Boiling,

Marjorie: Boiling.

John: Boiling. Yeah. Define evaporation from.

Marjorie: Oh, evaporation is when it moves from one state to another.

John: What

Marjorie: Whatsername

John: State to

Marjorie: To

John: What

Marjorie: Its

John: State would

Marjorie: Liquid

John: Like to

Marjorie: To

John: Again?

Marjorie: A gap. OK.

John: Okay. Evaporation

Marjorie: Operation.

John: Is when you're going from a liquid to a gas. Right. And we typically think of the evaporation occurring at the surface. Do we not?

Marjorie: Yes, we do.

John: Yeah.

Marjorie: Yeah,

John: Because

Marjorie: Because.

John: You have to be at the surface in order to escape into the

Marjorie: Rare.

John: Air.

Marjorie: Right.

John: Right. Here's

Marjorie: Here's.

John: The interesting thing. If you heat the water from underneath

Marjorie: Yes.

John: With a hot flame, you can get evaporation to occur beneath the surface. Remember, evaporation is going from the liquid to the gas rate.

Marjorie: So it moved to a liquid of gas before it gets out of the pan.

John: That's correct. Mm hmm. So envision, if you will, a pot of water,

Marjorie: I

John: I can

Marjorie: Can.

John: Take that pot of water and put it on top of a flame.

Marjorie: Yep.

John: I guess gas

Marjorie: Stove.

John: Stove.

Marjorie: Right.

John: Right. Imagine what it's like to be one of those water molecules down close to the bottom of the pan.

Marjorie: Well, you

John: Have

Marjorie: Have

John: To

Marjorie: To

John: Go

Marjorie: Go

John: Faster

Marjorie: Faster

John: In

Marjorie: And faster

John: Your

Marjorie: To get

John: Room

Marjorie: Out of the way from that heat

John: While

Marjorie: While

John: You're

Marjorie: You're

John: Moving

Marjorie: Moving

John: Faster

Marjorie: Fast

John: And

Marjorie: With.

John: Faster because of the heat.

Marjorie: Yes, right.

John: Right. And your neighbors are moving faster, faster. And if that heat is hot enough, you'll be moving so fast that you break apart from your neighbors and you form

Marjorie: Oh, really?

John: A gaseous phase

Marjorie: No kidding.

John: In your

Marjorie: You're

John: Still

Marjorie: Still in the

John: Undern

Marjorie: Water

John: In

Marjorie: In.

John: The water down at the bottom of the pan.

Marjorie: Well,

John: You

Marjorie: Wait

John: Wait a

Marjorie: A

John: Minute.

Marjorie: Minute,

John: Wait

Marjorie: Wait

John: A

Marjorie: A

John: Minute.

Marjorie: Minute, man. Why

John: Why will

Marjorie: Will

John: You

Marjorie: You

John: Separate?

Marjorie: Separate from your neighbors

John: Because

Marjorie: Because of

John: Of

Marjorie: All.

John: All that energy. Remember, it takes energy to separate water molecules from one another. Will look at that flame. You've got a lot of energy

Marjorie: So

John: To

Marjorie: All

John: Do

Marjorie: The

John: Just

Marjorie: Molecules

John: That to separate

Marjorie: Are separating

John: You from

Marjorie: From one another

John: Them in a little

Marjorie: Little area,

John: Area

Marjorie: But

John: You

Marjorie: What's left

John: Left in

Marjorie: In between?

John: Between nothing.

Marjorie: Nothing.

John: The water molecules are in a gaseous phase down underneath at the bottom of

Marjorie: Is

John: That

Marjorie: It boiling

John: Pan.

Marjorie: It?

John: Well, what happens now is you have a ba ba ba ba ba ba ba ba

Marjorie: Bubbles

John: Ba ba ba bubble.

Marjorie: Double.

John: You have a bubble because you have a gashes phase, do you not?

Marjorie: Yeah.

John: In

Marjorie: In

John: The

Marjorie: The gashes

John: Gashes phase

Marjorie: These.

John: Occupies

Marjorie: Oh,

John: More volume, right?

Marjorie: Yeah, that's

John: That's

Marjorie: Right.

John: Right. In

Marjorie: In

John: That

Marjorie: That.

John: Bubble will form at the bottom of the pan.

Marjorie: And go

John: You

Marjorie: To

John: Might

Marjorie: The

John: Have.

Marjorie: Top.

John: You

Marjorie: You

John: Might

Marjorie: Might have

John: Have

Marjorie: Seen

John: Seen it

Marjorie: It before.

John: Before.

Marjorie: I see.

John: And what happens next after that bubble forms and

Marjorie: It goes to the top

John: It rises

Marjorie: Is.

John: To the top. So here we've got the flame heating the water from underneath a water molecule in another water molecule separate into a gaseous phase. Underneath that, the bottom of the pan of water and they form a tiny bubble because

Marjorie: Yes.

John: They're

Marjorie: They're

John: Forming

Marjorie: Forming.

John: A gaseous

Marjorie: Yes, right.

John: Phase.

Marjorie: Right.

John: Once that bubble forms, buoyant forces take over and it rises to the top

Marjorie: In

John: And bursts

Marjorie: Bursts.

John: And bursts into the atmosphere.

Marjorie: That's right.

John: So what you have here is evaporation occurring at the bottom

Marjorie: At

John: Of the

Marjorie: The

John: Pan.

Marjorie: Bottom of the pan

John: Better

Marjorie: Is net

John: To say

Marjorie: Fascinate

John: Evaporation

Marjorie: Operation.

John: Occurring

Marjorie: Wow,

John: Beneath the

Marjorie: This

John: Surface.

Marjorie: Whole new.

John: And when that evaporation occurs beneath the surface, you form a bubble. In that bubble rises to the top.

Marjorie: That's what boiling

John: And

Marjorie: Is.

John: We call it boiling.

Marjorie: Isn't

John: Isn't

Marjorie: That

John: That

Marjorie: Amazing?

John: Amazing? There

Marjorie: There you

John: You

Marjorie: Go.

John: Go.

Marjorie: I

John: I

Marjorie: Never

John: Never knew

Marjorie: Knew that

John: That before.

Marjorie: Before.

John: Let's talk about that bubble now. Showy.

Marjorie: Yes.

John: In order for that bubble

Marjorie: To

John: To form,

Marjorie: Form.

John: It has to have enough pressure, internal pressure for it to form. You add a lot of heat, you're getting your water molecules moving really fast

Marjorie: As

John: And they're

Marjorie: A.

John: Going to punch, punch, punch their way into a bubble here. But you also have the weight of all the water above it trying

Marjorie: It's.

John: To push that bubble back in.

Marjorie: Right. Right.

John: In fact, that's why the bubble won't form at lower temperatures.

Marjorie: But wait a minute. It has a buoyancy about it that overcomes

John: A what? Once

Marjorie: This, it

John: It

Marjorie: Forms

John: Forms, once

Marjorie: What's

John: It

Marjorie: Ok.

John: Forms. Absolutely.

Marjorie: Absolutely. Oh, okay.

John: But

Marjorie: But

John: At

Marjorie: At

John: Lower

Marjorie: Lower,

John: Temperatures,

Marjorie: Temperatures

John: The

Marjorie: Are

John: Pressure,

Marjorie: Short.

John: The water pressure. Any bubble that forms just squishes back

Marjorie: Oh, I

John: In.

Marjorie: Know. But like you can see, when you're boiling, something is first it begins to bubbles form around the edges of the pandas.

John: Where it's hottest in a bubble will only form when it's able to push against the pressure of the water above it. You know, with deep you go in a swimming pool, the greater the pressure you feel. It's because of the weight of the water all above you. If you ever dive to the bar, to the bottom of a foot swimming pool.

Marjorie: When do you think is the last time you're talking to your mother?

John: Well, the pressure of the

Marjorie: The

John: Water,

Marjorie: Waters

John: Though.

Marjorie: Get.

John: That's from the weight of the water push is pushing against your eardrums and that hurts. So the deeper you are, the greater the pressure. Now, c'mon, you've got a pot of water. That bubble is underneath the water. That water has weight. The weight of that water is going to compress that bubble out of its

Marjorie: Why

John: Existence.

Marjorie: Doesn't it compress it?

John: It does. And that's why you won't form a bubble at anywhere below 100 degrees Celsius or 212 degrees Fahrenheit. Say

Marjorie: All right.

John: You say

Marjorie: All right.

John: Pick

Marjorie: Any

John: A

Marjorie: Temperature

John: Temperature, any

Marjorie: At

John: Temperature, 80,

Marjorie: 80 degrees

John: 80 degrees

Marjorie: Celsius

John: Celsius. OK,

Marjorie: Or

John: 80

Marjorie: 80 degrees

John: Degrees Celsius.

Marjorie: Celsius? You

John: You notice

Marjorie: Notice.

John: You still have heat coming up and a bubble might want to form. But there's not enough heat to allow the bubble to fight against the pressure of the liquid water. You're going to have to raise it to 200 degrees Fahrenheit, 100 degrees

Marjorie: Sulayman?

John: Celsius. And at that point, at that point,

Marjorie: Ok.

John: There is enough thermal energy for the bubble to form. All right. We call that the boiling point in the

Marjorie: Only

John: Boiling

Marjorie: Temperature.

John: Temperature. OK.

Marjorie: Ok.

John: The temperature at which a bubble conform against the pressure.

Marjorie: Do it

John: So

Marjorie: So

John: Evaporation

Marjorie: You can reach.

John: Is when you go from a liquid to gaseous face. All that's special about boiling is

Marjorie: It happens

John: Happens.

Marjorie: Faster. No,

John: No,

Marjorie: It

John: It happens

Marjorie: Happens

John: Beneath

Marjorie: Beneath

John: The

Marjorie: The

John: Surface

Marjorie: Surface, beneath

John: Of the

Marjorie: The

John: Surface.

Marjorie: Surface,

John: That's

Marjorie: That's right.

John: Right. Yeah. So the pressure pushes the bubble inward. In

Marjorie: Yeah,

John: Order

Marjorie: For

John: For that

Marjorie: That

John: Bubble

Marjorie: Bubble.

John: To form, it has to fight against the pressure of the water above it. But not just the water above it. There's the air pressure

Marjorie: Air

John: Above

Marjorie: Above

John: The

Marjorie: The water.

John: Water itself.

Marjorie: Yes, that's right.

John: It's the pressure exerted by the water, plus the pressure of the atmosphere.

Marjorie: There's an awful lot of pressure against it.

John: So the air pressure is important as well, which explains when you go up to higher elevations

Marjorie: Some.

John: Where there's less air pressure.

Marjorie: Oh, yeah.

John: That makes it easier. For the bubbles to form.

Marjorie: Oh,

John: That's

Marjorie: That's

John: Right,

Marjorie: Right,

John: It

Marjorie: It

John: Does.

Marjorie: Does.

John: You'll find the bubbles can form at a high altitude at a temperature

Marjorie: Temperature.

John: Much lower than, say, 100 degrees Celsius.

Marjorie: Oh, of course.

John: Yeah.

Marjorie: Yeah.

John: So say you're at 5000 feet

Marjorie: Half

John: Here,

Marjorie: Dry.

John: 8000,

Marjorie: Eight thousand

John: 8000

Marjorie: Eight.

John: Feet. The boiling temperature is going to be less

Marjorie: Lou,

John: Like maybe ninety

Marjorie: Ninety

John: Five

Marjorie: Five degrees.

John: Degrees Celsius.

Marjorie: You'd really have to

John: What's

Marjorie: Watch

John: That?

Marjorie: That pot.

John: Yeah, well, OK. So let's say in Denver, the boiling temperature might register 95 degrees, whereas that sea level where there's more air pressure, the boiling point would be 100 degrees. They're both boiling. But guess which is cooler? The ninety five degree boiling water or the hundred degree boiling water?

Marjorie: The 94 0 8 with the same.

John: No. Ninety five degrees. I grant you it was cooler than 100 degrees, so it's cooler.

Marjorie: But

John: It

Marjorie: It's

John: Boils

Marjorie: Boiling.

John: At a cooler temperature.

Marjorie: Ok. OK.

John: Yeah. Go to the Mount Everest and you'll find the water will boil at, what, sixty seven degrees Celsius?

Marjorie: Sure.

John: Yeah.

Marjorie: Yeah.

John: Lower

Marjorie: Lower

John: Temperature.

Marjorie: Temperature.

John: Okay.

Marjorie: Ok.

John: So

Marjorie: Say

John: Say in

Marjorie: It.

John: Denver though, it boils at ninety five degrees. Do you understand now how it is that it takes longer to cook an egg.

Marjorie: O o o.

John: In one case at sea level you're cooking at 100 degrees in Denver. You're cooking at ninety five degrees. They're

Marjorie: They're

John: Both

Marjorie: Both

John: Boiling,

Marjorie: Boiling.

John: But one's cooler.

Marjorie: Because

John: In Denver,

Marjorie: It was.

John: It's boiling at ninety five. It's boiling at ninety five degrees.

Marjorie: Well, that's because it doesn't have as much air pressure on

John: That's

Marjorie: Us,

John: Right.

Marjorie: Right?

John: So that's why it takes longer to cook an egg

Marjorie: Yeah,

John: At higher

Marjorie: Higher

John: Elevations.

Marjorie: Elevation. Yeah.

John: You could do the reverse, but use the collar. A pressure cooker where you seal the top. Yes. And the pressure builds up. And as the pressure accumulates inside, that makes it all the harder for those bubbles to form. Now, doesn't it?

Marjorie: They cook it faster because it's hotter.

John: Yep. It's not the boiling that cooks. It's the heat that cooks. So in a pressure cooker, the bubbling won't happen until you get to like a hundred and twenty degrees Celsius. That means it's a hotter temperature. The food will cook faster

Marjorie: Yeah,

John: In a pressure

Marjorie: Sure.

John: Cooker

Marjorie: Yeah.

John: Because the boiling temperature is now higher. Well, more thing. Isn't it interesting that as water boils, the temperature never rises beyond the boiling point? I mean, think about it. You're adding tons of heat. If the temperature doesn't rise, it remains constant. How so? Remember how evaporation is a cooling process? Yeah, that includes boiling, boiling, because it's a form of evaporation is a cooling process. You might be heating the water from below, but the boiling itself cools it right back down.

Marjorie: Oh.

John: Yeah, while boiling the rate at which the water heats up, it's equal to the rate at which it cools down, so the temperature, while boiling, remains constant. And we call that constant temperature the boiling point.

Marjorie: That's wonderful.

John: In the next section, we're gonna be talking about the specific heat of water. So when we talk

Tracy: Talk

John: About

Tracy: About.

John: Traci, hey, hey,

Tracy: Hey,

John: Guys,

Tracy: Guys, how's

John: Let's

Tracy: It

John: Go.

Tracy: Going?

John: Come on in. I

Tracy: I heard

John: Heard

Tracy: Margery's

John: Margery's here.

Tracy: Here.

John: Yeah.

Tracy: Yeah.

John: Yeah.

Tracy: Know.

John: Hi,

Marjorie: Hi,

John: Tracy.

Marjorie: Tracy,

John: It's

Marjorie: It's so

John: So

Marjorie: Good

John: Good

Marjorie: To

John: To

Marjorie: See

John: See you.

Marjorie: You. Come

John: Come on

Marjorie: On

John: In.

Marjorie: In.

Tracy: Oh,

John: Oh, nice

Tracy: Nice

John: To

Tracy: To

John: See

Tracy: See

John: You.

Tracy: You, Marjorie.

Marjorie: Join us

John: In

Marjorie: In this

John: This

Marjorie: Conversation

John: Conversation

Marjorie: About

John: About water,

Marjorie: Water.

John: What

Tracy: What

John: Do

Tracy: Do

John: You

Tracy: You

John: Guys

Tracy: Guys where

John: He

Tracy: He

John: Is

Tracy: Is

John: Working

Tracy: Working

John: On?

Tracy: On?

John: We

Tracy: We.

John: Got up to specific heat.

Tracy: Are

John: Are

Tracy: You

John: You in

Tracy: In

John: The

Tracy: The middle

John: Middle

Tracy: Or

John: Or

Tracy: Just

John: Just now?

Tracy: Starting?

John: We're just we're

Tracy: We're just

John: Just starting

Tracy: Starting.

John: In specific

Tracy: Oh,

John: Heat. Good

Tracy: Good

John: Timing.

Tracy: Timing. Okay.

John: Okay. Okay.

Tracy: Perfect.

John: You ready? Yeah.

Tracy: Yeah.

John: All right. So we should make sure we all understand temperature first. OK, so yes, temperature, you'll recall, is a measure of how fast the molecules are moving like

Tracy: Like

John: Kinetic

Tracy: Kinetic energy,

John: Kinetic

Tracy: Kinetic

John: Energy.

Tracy: Energy,

John: Kinetic

Tracy: Kinetic

John: Means motion

Tracy: Motion.

John: And temperature is a measure of the average kinetic energy. Some are moving a little slower, some moving a little faster. But the average speed of all those molecules is really what temperature is. And how do you raise the temperature of something? Mom usually

Marjorie: Usually

John: Apply

Marjorie: Apply heat.

John: Heat. Yeah. Heat. So heat is what you apply to increase the temperature. Got that. Now consider you have an empty iron skillet on the stove.

Tracy: Ok, you got an iron skillet

John: On

Tracy: On

John: The

Tracy: The

John: Stove.

Tracy: Stove.

John: And we're gonna put the stove on high.

Tracy: Ok. You're going

John: This

Tracy: To

John: Is

Tracy: Heat

John: Say it's

Tracy: Up a empty pan,

John: An empty

Tracy: Empty

John: Pan.

Tracy: Pan.

John: Nothing

Tracy: Ok.

John: In the pan.

Tracy: Ok, wait. Why an iron skillet?

John: We want to simplify it so we have just iron atoms in there without anything in the skillet. We're gonna put it on the flame. What's going to happen to the average speed of those iron atoms?

Marjorie: They're going to speed up.

John: Yeah, and it gets hotter. Pretty soon you're not going to want to touch that

Marjorie: That

John: Skillet.

Marjorie: Skillet truant.

John: Correct.

Tracy: Exactly

John: The

Tracy: The

John: Temperature

Tracy: Type.

John: Rises pretty quickly. Now, there's a different scenario when we talk about water. Now let's take a large pot of water. Liquid water. We want to make some spaghetti. So we have a big pot of water and we put that on the stove. And I would grant you that that water would be just as heavy as the iron skillet. Now, take that water and put it on the stove. How long's it take to heat up?

Tracy: What do you think? Marjorie?

Marjorie: Maybe 10 minutes.

John: It takes a while, it takes a while to heat up. How come it takes so long to heat up the water? Yet the iron heats up so fast and it's the same stove, the same stovetop, the same flame. Why does it take so much longer for the water? Anybody?

Tracy: Does this have anything to do with the stickiness we were talking about last time?

John: Yep, the stickiness. Now, as you add the heat to the water. Yeah. Some of that heat is going to making the water molecules move faster. This is true. But there's something else that's going on with your water molecules. The water molecules are connected to each other by that dipole, dipole, attraction, rain.

Tracy: Right.

John: As you add the heat, a lot of that heat energy is not going to making them all move faster. All it's doing is going in there to separate them.

Tracy: You mean to. To separate them and take apart that dipole, dipole interaction?

John: Yes.

Tracy: Yes, that's a pretty strong interaction

John: It's

Tracy: That

John: A

Tracy: Must

John: Strong

Tracy: Take

John: Interaction.

Tracy: A lot of energy.

John: It takes energy to do that. Think of two magnets. If you went to two magnets to be pulled apart, you recognize it would take energy to do that. Yeah. Same thing with two water molecules. If you wanted to pull those two water molecules apart from each other, that's going to take energy to do that. And as you heat up the water, that's exactly what's happening down there in the molecular level as the water gets hotter and hotter. There are fewer and fewer dipole dipoles. You're breaking them apart. That takes energy.

Tracy: Okay, cool.

John: So

Tracy: So.

John: It takes so long to heat up the water because a lot of that energy is not making the water molecules move faster. Rather, it's going in there to help separate the water molecules from each other.

Tracy: Can you describe this with our fists?

John: Ok. So you have to fist each fist represents a water molecule. Right now put your fist together and your fists. There you go. Your fists are together. Represents two water molecules that are stuck together,

Marjorie: Together

John: Right

Marjorie: Vibrating.

John: In any other vibrating a bit, too. Let's add that. Now, what we're going to do is going to add some heat in the heat is going to make a move faster. Right.

Tracy: Right. But they have a dipole, dipole interaction, so they

John: Keep

Tracy: Have

John: To

Tracy: To

John: Stay.

Tracy: Stay close together

John: They're still

Tracy: Still.

John: Stuck together.

Tracy: Right. OK.

John: But you get

Tracy: Get to.

John: To a point where suddenly they break apart from each other. And

Tracy: And

John: As

Tracy: As

John: Soon

Tracy: Soon as

John: As

Tracy: They

John: They

Tracy: Do,

John: Do, they

Tracy: They

John: Know

Tracy: Know

John: They

Tracy: They.

John: Relax,

Marjorie: They relax,

John: Relax.

Marjorie: I

John: I

Marjorie: Should think

John: Think they

Marjorie: They

John: Would

Marjorie: Would

John: Be

Marjorie: Be nervous.

John: Nervous.

Marjorie: Well, they lost part of themselves.

John: They've lost part of themselves.

Marjorie: I do know that.

Tracy: They lost their there.

John: No, they didn't.

Tracy: They didn't

John: In

Tracy: Lose

John: This part

Tracy: Part

John: Of

Tracy: Of

John: Themselves,

Tracy: Themselves,

John: They

Tracy: They

John: Lost

Tracy: Lost

John: Their

Tracy: Their

John: Companion.

Tracy: Companion.

Marjorie: Precisely.

John: Precisely.

Tracy: Ok. That's significant.

John: What's

Tracy: Was

John: Happened

Tracy: Half.

John: Is the energy that kinetic energy has transformed into potential energy. You now have those two water molecules apart from each other. Do the reverse. Bring them together. Notice they accelerate toward

Marjorie: Of

John: Each

Marjorie: Course,

John: Other, don't

Marjorie: Only would.

John: They? They go like that. Yeah. So as they accelerate toward each other, they speed up.

Marjorie: I

John: Get

Marjorie: Get

John: That.

Marjorie: That a house.

John: They speed up as they come toward each other. Do the reverse. They'll slow down as you separate them.

Tracy: It is like magnets on.

John: Yes, the magnets, you have a magnetic force, North Pole, South Pole. But with these dipoles molecular dipoles, you have positive undecided, slightly negative on that side. It's more of an electrical force,

Marjorie: But

John: But the

Marjorie: The idea

John: Idea

Marjorie: Is

John: Is the

Marjorie: The same.

John: Same. If you want to pull two magnets apart, it takes energy to do that. And after that separation, you'll find Combe. Why? Because if they're coming together means they move faster than they're coming apart. Means they'll be moving slower. Think of it this way they'll be exhausted after overcoming the force that otherwise holds them together, so the energy that you're putting into warm up the water. A lot of it's going to pulling water molecules away from each other, which get this causes them to slow down. It's

Tracy: And

John: Going to

Tracy: Then

John: Get.

Tracy: If they slow down after then the kinetic, the average kinetic energy isn't that much higher

John: Yeah, and what's happened is the energy

Tracy: Energy.

John: That you're putting in is going into greater potential energy. Back with the iron. It's all going into greater kinetic energy. But with the water, the heat, a big chunk of the heat that you're putting in there is going into not kinetic energy, but increased potential energy.

Marjorie: What do you mean potential energy?

John: Potential energy, as we learned from physics, is the energy of position. Take a rock and put it up on a ladder. By virtue of its position, it has the potential to fall down to the ground. So you have two types of energy energy position, which is potential. And you look at that rock up on the ladder and go, well, that would really hurt if they hit my head. If it fell down, it has the potential to do something versus kinetic energy, which is the energy of motion. You look at a car speeding down the highways, a well, that could really hurt me if it hit me. Kinetic energy is the energy of motion. Potential energy is the energy of position. So when

Marjorie: When

John: You

Marjorie: You

John: Separate

Marjorie: Separate.

John: Two water molecules, look, you've changed their

Tracy: Position.

John: Position relative to each other. So the heat is going to increasing the potential energy of the whole system. That's something really cool about water. It takes forever to heat it up.

Marjorie: That's cool.

Tracy: That's hot.

Marjorie: And

John: And

Marjorie: You

John: You

Marjorie: Know

John: Know,

Marjorie: It.

John: It takes a long time to heat up a pot of water. Let's look at the reverse. You know, it takes a long time for the pot of water to cool down.

Tracy: Nia?

John: Now consider as it cools down, water molecules slow down. That's going to permit them to come back together to form dipole dipoles. And as they come back together to form dipole dipoles, they release energy. Remember, the forming of a bond releases energy like two magnets coming together. When the two met two little magnetic marbles, they come together, they'll accelerate toward one another, increasing their speed. And once they they hit, they'll start spinning around really fast. You will see with two magnetic marbles that as they roll together, suddenly they're moving a lot faster. Why? Because they're accelerating wide, accelerating towards each other. Because there's a force, a magnetic force. In this case, we're talking about an electrical force of attraction. As to water molecules accelerate toward one another, they start moving faster, moving faster. Hey, that's kinetic energy. So as the water cools down, it releases heat.

Tracy: What

John: As

Tracy: As

John: It

Tracy: It

John: Cools

Tracy: Cools

John: Down,

Tracy: Down,

John: More

Tracy: More

John: Bonds

Tracy: Bonds

John: Have

Tracy: Are

John: Formed.

Tracy: Formed.

John: Heat

Tracy: Heat

John: Is

Tracy: Is

John: Released.

Tracy: Released, so

John: It

Tracy: It

John: Wore

Tracy: Heats itself back.

John: It

Tracy: It wants

John: Warms

Tracy: It

John: Itself

Tracy: Again.

John: Back

Tracy: Back

John: Up.

Tracy: Up.

John: Yes,

Tracy: Yes.

John: It cools down. It forces self backup. And you have to wait for that heat to dissipate out into the environment and then it cools down a little bit more and then you have more dipole dipoles form. And it hits itself up again

Marjorie: When

John: When

Marjorie: It

John: It

Marjorie: Dissipates

John: Dissipates

Marjorie: To

John: To the

Marjorie: The environment

John: Environment

Marjorie: Is that when it

John: Becomes

Marjorie: Becomes to

John: To

Marjorie: Some

John: Some extent

Marjorie: Extent

John: The

Marjorie: A gas.

John: Gas. No, no, no. It's just the heat radiating outward into the environment. You have to have that heat removed from the system. Understand, as soon as those water molecules come back together upon cooling down, they heat themselves back up. And if

Tracy: Which

John: That

Tracy: Means

John: Means

Tracy: That the kinetic

John: Kinetic

Tracy: Energy

John: Energy increases.

Tracy: Increases,

John: Yeah.

Tracy: That average kinetic energy increases.

John: And if that, in fact, heat is not extracted, it's never gonna cool down. And that's what happens inside a thermostat. Oh, yeah. Because you cut off the means of extracting that heat and so

Marjorie: So

John: It

Marjorie: It just

John: Just stays

Marjorie: Stays

John: What

Marjorie: There.

John: It is

Marjorie: How about that?

Tracy: So it goes from potential energy

John: Back

Tracy: Back

John: To

Tracy: To

John: Kinetic

Tracy: Kinetic energy.

John: As it cools back down and heating itself back up effectively. So it's a very special property of water to have such a relatively high heat capacity, we call it the technical term is specific heat. I actually prefer the term heat capacity. It's like a sponge. Water is like a heat sponge. It can soak up heat very, very well. And it can hold on to that heat very, very well, which is why you have a water bottle with you at night. You know, hot water bottle helped keep you warm.

Tracy: And

John: And that

Tracy: That

John: Can

Tracy: Can

John: Last

Tracy: Last like

John: Through

Tracy: Through

John: The

Tracy: The

John: Night.

Tracy: Night.

John: Yeah. And there's very interesting environmental application of this having to do with our oceans. I mentioned the sand at night at a beach you'll find is really cold in the nighttime. The sand can't hold onto heat very well. It releases the heat right away at night, nighttime after sunny day on the beach. After that sunny day on the beach at nighttime, the sand feels pretty darn cold. Put your feet in the water. You'll feel the water feels relatively warm. The water does not change its temperature very easily. And if you look at the planet on a grand scale, we talk about global warming due to greenhouse gases. Ninety percent of the heat, the added heat to our planet is not to our atmosphere. It's to our oceans. The temperature of our oceans has been increasing. There's a lot of focus on the atmospheric temperature. Yeah, that that's important for sure. But what's key is understanding that most of that added heat to our planet is going to our oceans. We can think our oceans big time for being there. They moderate the temperature because they can absorb the heat. So well, the temperature doesn't go up. Right. And if you live in a place like Iceland or an island place like Hawaii, you'll find that the temperature variations from day to night are not that much. Why? Because the water is moderating the temperature, right?

Tracy: Right. Actually, you

John: You can

Tracy: Can

John: Even

Tracy: Even

John: Find

Tracy: Find that

John: That in

Tracy: In temperate

John: Temperate areas

Tracy: Areas

John: Like

Tracy: Like

John: Halifax,

Tracy: Halifax, you

John: Nova.

Tracy: Know, in in maritime areas.

John: Right.

Tracy: Right.

John: It'll

Tracy: It

John: Be

Tracy: Is.

John: Cooler than it is in Hawaii, but you'll find the temperature variations are not that great as opposed to a place like the middle of a continent like like Kansas

Tracy: So like Boulder

John: And

Tracy: And

John: Boulder,

Tracy: Boulder.

John: Where you're going to have great variations in temperature. You don't have the water around you to moderate those temperature changes. But when it comes to climate change, it's important. We recognize that the heat added heat to our planet is primarily going to our oceans and couple consequences of that. Can you think of some?

Marjorie: Fish who need a cooler water will have problems and have to travel to find a place that is cooler. But

John: Is

Marjorie: Is there a place it's cooler?

John: The fish would have to migrate

Tracy: Migrate

John: To

Tracy: Or

John: More polar

Tracy: Cooler

John: Climates.

Tracy: Climates.

John: That's

Tracy: But

John: Right.

Tracy: We're seeing

John: The

Tracy: The

John: Coral

Tracy: Coral

John: Reef

Tracy: Reefs

John: Section

Tracy: Actually they

John: They

Tracy: Have

John: Have

Tracy: Issue with

John: There

Tracy: There is

John: Is

Tracy: Rise

John: Rising

Tracy: In

John: Temperature

Tracy: Temperature

John: And

Tracy: And

John: They

Tracy: They

John: Can't

Tracy: Can't

John: Just

Tracy: Just get

John: Get up

Tracy: Up and move.

John: And

Marjorie: No.

John: Get

Marjorie: So

John: A

Marjorie: They

John: Guy.

Marjorie: Guy.

John: So there's that there's an impact on the biosphere within the hydro sphere.

Marjorie: What if the water changes and starts cooling off again? Would

John: Well,

Marjorie: They come back?

John: But remember, water takes a long time to change its temperature. It really does.

Marjorie: Oh, my.

John: Ok. So an effect on the aquatic organisms. That's one. Get another one. When you're adding heat to the oceans, what happens to the volume of water when you warm it up?

Tracy: It increases,

John: The volume

Tracy: Volume

John: Increases

Tracy: Increases,

John: So

Tracy: It expands.

John: It expands. As you warm up the oceans, you're going to have an expansion of the water, which would lead to

Marjorie: Flooding

John: Flooding higher

Marjorie: Higher.

John: Sea levels.

Tracy: Rising sea levels.

John: Yeah, and flooding along coastal areas. That's for sure. And.

Marjorie: I thought it was because glaciers were melting and just increasing the amount of water, and that's what made for.

John: That's true also. But the increase in sea level simply due to the expansion

Marjorie: Spansion

John: Of

Marjorie: Of

John: The

Marjorie: Land

John: Warmer

Marjorie: And

John: Water

Marjorie: Water

John: Is

Marjorie: Is.

John: Also significant

Marjorie: So

John: As

Marjorie: It's

John: Well.

Marjorie: Twofold.

John: Twofold for sure. First, to understand that water, it takes a long time to heat up.

Tracy: Ok.

John: That is to say that you can add a lot of heat to it in the temperatures. Not going to go up very well if it weren't for our oceans or global temperatures would be way, way higher right now.

Tracy: So if the ocean is getting heated up, the heat is going to separating the water molecules.

John: The energy is going to separate in the water molecules, and that's how the oceans are able to hold on to that heat.

Tracy: So

John: So

Tracy: There's

John: There's that's

Tracy: That's what

John: True.

Tracy: The expansion

John: You

Tracy: Is.

John: Know, it holds on to that heat. The heat going in and the temperature will slowly rise. It will slowly rise. Thank goodness. But it will rise. And as it rises, so you will find an increase in its volume just by thermal expansion.

Marjorie: Let me ask you this. As the glaciers melt and more water is added to the ocean. Does that change how long it's going to take for them to get too warm for the planet's

John: So

Marjorie: Good?

John: The melting

Marjorie: Melting

John: Glaciers

Marjorie: Glaciers

John: Would

Marjorie: Would

John: Have

Marjorie: Have a

John: A cooling

Marjorie: Cooling

John: Effect

Marjorie: Effect.

John: Now?

Marjorie: Yes.

John: Yeah, wouldn't they?

Marjorie: Yes,

John: Yeah, I

Marjorie: I

John: Would

Marjorie: Would

John: Think.

Marjorie: Think yes.

John: Yeah, but don't forget, glaciers are freshwater. So the melting of a glacier also means dumping a bunch of freshwater into the oceans. And most significant issue with that is the potential for disturbing ocean currents such as the Gulf Stream

Tracy: Ok.

John: And

Tracy: Yeah.

John: Mess with the direction of ocean currents. And well, ouch. That's yet another climate change agent that do consider a place like Greenland. There's just so much land bound ice melt. Just Greenland alone in sea levels go up by five to seven meters. That that's just the math. If Greenland melted, then you'd also expect some melting of the Antarctic ice sheet to write melt all of Antarctica. Though that's not likely anytime soon with current models. But if the dead melt all of Antarctica, sea levels go up by another 60 metres. That's about 200 feet.

Tracy: Wow, that's a lot.

John: That that's the potential danger we're facing. We're talking planetary scales in 50 percent of the world's population lives along the coastal areas.

Marjorie: And

John: And how

Marjorie: How

John: Fast

Marjorie: Fast

John: Is

Marjorie: Is it

John: It

Marjorie: Melting?

John: Melting?

Marjorie: Is it going

John: We

Marjorie: To.

John: Don't know. We don't know whether it's going to accelerate or

Marjorie: Stabilize.

John: It's good or. Well, no, it's definitely melting. But the question is, how fast is it melting? And are there feedback loops to make it melt even faster?

Marjorie: Have

John: Have we

Marjorie: We

John: Reached

Marjorie: Reached

John: A

Marjorie: A point

John: Point of

Marjorie: Of

John: No

Marjorie: No

John: Return

Marjorie: Return?

Tracy: Kick. Let's

John: To

Tracy: Go back to

John: Specific?

Tracy: Specific. Just just because

John: There's

Tracy: We're

John: One

Tracy: Getting

John: More

Tracy: Lower.

John: Effect that needs to be mentioned here.

Marjorie: If it takes a long time for a pot of water to cool down, it's going to take a longer time for a notion to cool down.

John: Yeah, so it's nothing that's going to change overnight. It's been well over a century that we humans have been having this impact, this Collective impact say it takes 100 years for it to warm up to by one or two degrees. It's going to take 100 years for it to cool down by one or two degrees.

Marjorie: Oh, dear.

John: It's here to stay relative to our lifespans. Yeah. Heat capacity or specific heat is a very important subject, not just in terms of why does it take so long for a pot of water to heat up. It also asked very important implications when it comes to climate change and global warming.

Tracy: So you talk about the specific heat of water, do you talk about specific heat of other substances?

John: Water has a specific heat of let's look at this table of four point twenty four joules per gram per degrees Celsius. It's relatively high ammonia one.

Tracy: Way, way, way, I think you need to describe what these numbers are. How many joules does it take to.

John: Heat up

Tracy: 1

John: One gram

Tracy: Gram.

John: Of water by one degrees Celsius.

Tracy: That

John: That

Tracy: Is

John: Is the

Tracy: The

John: Measure

Tracy: Measure

John: Of

Tracy: Of

John: Specific

Tracy: Specifically.

John: Heat. There you go. So for water, it's four point twenty four joules are required to heat up one gram by one degrees Celsius. That's what that means. What's a jewel? Mom, you're asking earlier? It's about the amount of energy that's released when you light a match and then blow it out. Oh,

Tracy: That's

John: That's a

Tracy: A

John: Lot.

Tracy: Lot of energy.

John: So for liquid water, it has a heat capacity of four point one. Heat four. Check this out. The heat capacity of ice is two point zero. It's half.

Tracy: Why

John: Why would

Tracy: Would

John: That

Tracy: That

John: Be

Tracy: Be?

John: Ok?

Tracy: Ok, wait.

John: Let's

Tracy: Let's think

John: Think

Tracy: About this.

John: Why

Tracy: Ok.

John: Is

Tracy: We

John: The

Tracy: Can do this

John: Why

Tracy: Thing on

John: Is

Tracy: The.

John: The heat capacity of ice half that of liquid water, it's still H2O.

Tracy: Right. But let's see, ice is expanded, so there's more space between it.

John: Are you breaking dipole, dipole bonds when you go from minus 50 to minus 40, minus 50 as ice minus 40 is ice. It's still ice. It's below zero. So as you go from minus 50 degrees Celsius and you want to bring it to minus 40 degrees Celsius, what you have to do.

Tracy: Add

John: Heat

Tracy: Heat,

John: Add

Tracy: Add.

John: Heat. That's

Tracy: That's

John: Right.

Tracy: Right.

John: But notice that heat is not meaning to break any dipole dipole bonds.

Tracy: So you don't have to add that much heat.

John: That's correct.

Tracy: So it takes less.

Marjorie: Unless.

Tracy: Jewels per gram to heat that ice up by 1 degrees Celsius.

John: Guess

Tracy: Guess

John: It's

Tracy: It's

John: It's

Tracy: It's

John: All

Tracy: All

John: That

Tracy: That. Got

John: Is

Tracy: It.

John: All

Tracy: All

John: That

Tracy: That

John: Is

Tracy: Is

John: Going

Tracy: Going

John: To

Tracy: To.

John: Make the molecules vibrate faster, you're not having to break the dipole dipoles. So that is with the liquid water. It's really an interesting and unique situation that we've gotten. And thank goodness, I mean, otherwise our planet would not be habitable. There's this one last section with a phase change requires the input or output of energy. This wrap that up really quickly here. It takes energy to increase the temperature of water. But when you want to go from solid water to liquid water, you're having to do this phase transformation and that is doing nothing but breaking apart the dipole, dipole, bonds. And it does nothing to increase the kinetic energy. So it takes energy to change the face, but the temperature does ever go up. So you add heat to ice at zero degrees, it'll melt and it will still be zero degrees. So at what situation can you add? Heat and the temperature doesn't rise?

Tracy: When you have ice.

John: To liquid, yeah. And the same thing goes on when you try to go from a liquid to the gas. All the energy you're adding to the hundred degree liquid water goes to transforming it into 100 degree gas, just water. They're both at 100 degrees, but it's going to cost you like two thousand jewelers, that number here at two thousand two hundred and fifty nine joules to transform it from a liquid to a gas. Where's that energy going? Those two thousand two hundred and fifty nine joules. What's it doing? It's pulling apart the water molecules 100 percent from each other, complete

Marjorie: Oh, my goodness,

John: Separation,

Marjorie: Separation.

John: A complete separation of the water molecules. We talked about this quite a bit over time about liquid water that you're breaking the interactions. But when you get to transforming from a liquid water to gaseous water, you are breaking those interactions completely, not the covalent bonds within a water molecule, but the dipole, dipole interactions between molecules.

Marjorie: Can

John: Can

Marjorie: They

John: They ever

Marjorie: Ever

John: Meet?

Marjorie: Reverse the process?

John: Yeah. And when you take gaseous water and let it cool down, bam, a lot of heat comes out. Now, if you had your choice of getting scalded by 100 degree liquid water or 100 degree gaseous water, would you peg?

Marjorie: Why would there be a difference?

John: They're both hundred degrees rain. Well, when that gaseous water condenses. Tons of energy are released. And that explains hurricanes. Because over warm tropical waters, you

Marjorie: You

John: Have

Marjorie: Have

John: Water

Marjorie: Water

John: In the

Marjorie: Vapor.

John: Vapor phase. The water molecules come together and release a lot of energy. It warms things up, get a storm system that can develop around that. The driving force of any hurricane is the condensation of water. Going from a gaseous phase to a liquid phase is called con everyone condensation.

Tracy: Condensation.

John: When condensation happens, you have the formation of the connections between water molecules. You go in from where they're far apart and gas to weather together in a liquid. They're forming the dipole, dipole interactions and a lot of energy is released. Yeah. So if you're exposed to a hundred degree gaseous water, it's going to condense upon you and release a lot of energy. Steam burns are way more dangerous

Marjorie: To

John: Than hot

Marjorie: Help.

John: Water burns. Mm hmm. Hey, so we have some practical applications here. Watch out when you're ironing your clothes. Any other questions? Wow. And thank you, listeners, for joining us. Is it through this exciting chapter on water, the macroscopic properties as water arisen from its molecular properties?

Tracy: Sounds good. Good.

John: Good

Marjorie: Good

John: Chemistry

Marjorie: Chemistry

John: To

Marjorie: To

John: You.

Marjorie: You.

John: Theme Music by Zach Jefferey Musical Flourishes by George Frederic Handel, selections from his Water Music Suite in F Major. Our thanks to Majorie Hewitt Suchocki Emeritus Professor and Dean of the Claremont School of Theology Production Assistance from Greg Simmons and CPro Music for show notes and more. Please visit conceptualscience.com. A note of appreciation to all instructors using conceptual academy. Thank you for your support. And to the hardworking student. Our thanks to you as well for your learning efforts, which we see as the path to making this world a better place. There's a bigger picture. That's good chemistry. Good chemistry to you.