Big Picture Podcast – Episode 14

Molecular Interactions (Chapter 7B)

In this "Do-The-Review" episode, co-hosts John and Tracy Suchocki review the four main types of molecular interactions. This includes the dipole-dipole interaction as well as the ion-dipole, dipole-induced dipole, and induced dipole-induced dipole interactions. This is followed by a discussion of the many terms associated with solutions, such as solute, solvent, solubility, concentration, and the mole. The episode concludes with a discussion of reverse osmosis. Duration: 1:01.

Tracy: Welcome to the Big Picture podcast. In this episode, we're going to be looking at how molecules interact.

John: You mean, how they stick together.

Tracy: Yeah. How they mix and stick together?

John: Okay, first we have the idea of what a molecule is, right?

Tracy: A bunch of atoms stuck together.

John: Right. Stuck strongly together, so strongly together that the molecule you can look at it as a fundamental unit of matter. So like the most fundamental unit of water is the.

Tracy: Water molecule.

John: So the fundamental unit of water is the water molecule. Now you look at the water molecule and you all understand we all understand that it's made of atoms that are grouped together. You've got two hydrogen atoms linked up to a central oxygen atom. There is this angled between them all? Yeah. So we can distinguish what's going on within a molecule versus what goes on between molecules. Within the molecule, you've got the chemical ba ba ba

Tracy: Chemical

John: Ba.

Tracy: Bonds.

John: Bond, yeah. In this case, a covalent bond in those covalent bonds are strong right in. So they hold those atoms together very tightly, so tightly that the molecule itself behaves as a fundamental unit.

Tracy: Sounds good.

John: All

Tracy: So

John: Right.

Tracy: What

John: What are

Tracy: Are

John: We

Tracy: We

John: Going

Tracy: Gonna

John: To do

Tracy: Do with

John: With that?

Tracy: That?

John: Well, we just want to see where we are. What is it that holds the atoms together within a molecule? Right. And that would be the covalent, the Bubba

Tracy: Covalent bonds.

John: Bond. Now

Tracy: We also talked about

John: Some

Tracy: Some

John: Other

Tracy: Other

John: Bonds.

Tracy: Bonds to

John: Yeah,

Tracy: A.

John: They're ionic bonds and the metallic bond. But note, we're going to be specific here toward the covalent bond.

Tracy: Ok.

John: Ok,

Tracy: Good

John: Good to

Tracy: To

John: Know.

Tracy: Know.

John: All right. So we know what's going on within the water molecule. But what about between molecules?

Tracy: So we were talking about sticking. So how do they stick together?

John: Yeah. So

Tracy: So.

John: Water molecules, as we discussed before, they're really sticky. One side of the molecule is slightly negative and one side of the molecule is slightly positive. And we talked about that has everything to do with the geometry of the molecule and how oxygen pulls electrons toward itself preferentially away from the hydrogens. So the oxygen side of the water molecules slightly negative, making the hydrogen side of the molecule slightly positive.

Tracy: Positive.

John: Right. We did talk about this earlier, that when you have two water molecules and put them together, you're going to have the negative side of one molecule align to the positive side of a neighboring molecule in positives and negatives, the tracht. And so there is an attraction in electrical attraction between two separate molecules. And it's

Tracy: Ok,

John: Like,

Tracy: So

John: Yeah,

Tracy: What do

John: You

Tracy: You

John: Call

Tracy: Call

John: That

Tracy: That

John: Attraction.

Tracy: Attraction?

John: That's a good question.

Tracy: We call it sticky.

John: It's called stickiness,

Tracy: Okay.

John: But we do need to distinguish it from what's going on within the water molecule. We're talking between water molecules. Now, I could put it this way if the force of attraction between atoms within a molecule is 100. The attraction between separate water molecules is about five. It's much weaker.

Tracy: That's that's a big difference.

John: Yeah,

Tracy: Yeah.

John: It's a big difference and it has consequence in terms of the macroscopic properties of the material.

Tracy: Like

John: Liquid

Tracy: What?

John: Water is a liquid at room temperature.

Tracy: And then when you heat it.

John: It'll turn into a gas. You're using that heat to separate water molecules from each other and it goes from a liquid phase where all the molecules are tumbling over one another to a gaseous phase where the water molecules are moving fast, spaced far apart from each other. And if they do come in contact, it's just a collision of bounce collision like billiard balls.

Tracy: But they still stay as water molecules.

John: There's still water molecules, so that's a physical change as you go from the liquid phase to a a gaseous phase because

Tracy: And then it's.

John: You still have water molecules before and after.

Tracy: And then when you freeze the water.

John: When you freeze the water, you're pulling away energy so that those water molecules no longer have sufficient energy to tumble over one another. And the stickiness of the water molecules holds sway. All of those water molecules remain stuck in a fixed position. We call that a crystal.

Tracy: Ok.

John: So what we're going to focus on here are the interactions between molecules and we have just described one of them already.

Tracy: Which did you describe?

John: The dipole dipole attraction.

Tracy: Oh, okay. So the dipole, dipole, that's where you have the positive side of a molecule sticking. We're attracted to the negative side of an adjacent molecule.

John: Yeah, exactly. Now, we talked about earlier that when you have one side of the molecule slightly negative and the other side slightly positive, we have a term for that. We call it a dipole. We say that the water molecule has a dipole, one side slightly negative, one side slightly positive. And so here's one water molecule. The dipole and there is another water molecule with a dipole. What do you suppose we should call the interaction between those two dipoles?

Tracy: How about dipole, dipole?

John: You get real creative. It's the dipole, dipole attraction. If you understand a dipole, you'll understand the dipole dipole attraction. It's merely the attraction between two dipoles.

Tracy: On two different molecules.

John: Or between two parts within a very large molecule. Let's see, another one we can talk about is the ion dipole. Guess what that's all about?

Tracy: Let me guess. It's where an iron, which

John: She's

Tracy: Is

John: Going

Tracy: Going

John: To

Tracy: To

John: Have

Tracy: Have

John: A

Tracy: A

John: Positive

Tracy: Positive

John: Charge

Tracy: Charge

John: Or negative charge

Tracy: Or

John: And

Tracy: A negative

John: Negative charge,

Tracy: Charge,

John: But

Tracy: But it

John: A

Tracy: Has

John: Lesser

Tracy: A charge,

John: Charge.

Tracy: It will be

John: He

Tracy: Attracted

John: Attracted.

Tracy: To the opposite charge on a molecule that has a dipole.

John: Ok. Let's look at the interaction between salt and water. Salt is sodium chloride with what kind of bonding going on in their

Tracy: Ionic.

John: Ionic. You have a sodium ion and a chloride Iron City minus positive chloride ions negative. All right. So take some sodium chloride and throw it into a cup of water. What do you suppose happens?

Tracy: Well, I would say that the sodium of the sodium chloride is going to be attracted to the oxygen part of the dipole.

John: Excellent. So you're recalling that the oxygen side of the water molecule slightly negative

Tracy: Slightly negative,

John: Because

Tracy: So

John: It has

Tracy: Then.

John: This idea and the sodium ion is.

Tracy: Slightly positive,

John: No, it's not slightly positive.

Tracy: Very positive.

John: It's very

Tracy: Very

John: Positive.

Tracy: Ok.

John: It's an

Tracy: It's

John: Iron.

Tracy: Absolutely positive.

John: Yeah. It's

Tracy: It's

John: A matter

Tracy: An eye on.

John: Of. Yeah. It's all charges. It's a matter of how much charge a. So first an iron on the charges as much as it can be for a dipole. The charges. Typically when we're talking about this in context is significantly less. Now if you want to get into the nitty gritty detail, it tell you if you have a sodium chloride. I tell you, if you have sodium chloride ions next to each other, one side's positive. One side's negative. That is a huge dipole. You have a water molecule, one side slightly negative, one side slightly positive. That's a weak dipole. But the really the same thing where one side's negative and one side's positive, it's a matter of magnitude. All

Tracy: All

John: Right.

Tracy: Right, so then

John: The

Tracy: The

John: City.

Tracy: Sodium chloride doesn't actually separate in the water because that ionic

John: Bond

Tracy: Bond

John: Is

Tracy: Is

John: Actually

Tracy: Actually

John: Very,

Tracy: Very,

John: Very,

Tracy: Very,

John: Very,

Tracy: Very,

John: Very

Tracy: Very

John: Strong.

Tracy: Strong.

John: That's

Tracy: It's

John: True,

Tracy: True.

John: That ionic bond is very, very, very strong, but it is uniquely different from the covalent bond now, isn't it?

Tracy: All right.

John: In a covalent

Tracy: Valen

John: Bond,

Tracy: Bond

John: Electrons

Tracy: Electrons

John: Are

Tracy: Are

John: Being

Tracy: Being

John: Shared.

Tracy: Shared. All right. These are just a

John: Strong,

Tracy: Strong,

John: Strong,

Tracy: Strong,

John: Strong

Tracy: Strong

John: Attraction.

Tracy: Attraction.

John: The

Tracy: The.

John: Chlorine atom has yanked an electron fully away from the sodium. And so that chlorine is totally negative in charge and that sodium is totally positive in charge in inheres. What can happen when you throw that sodium chloride into the water? Those water molecules emphasis on the plural. There are many of them will start surrounding the sodium chloride ions. The negative side of the water molecules will start surrounding the sodium ion in three dimensions. Likewise, the hydrogen side of the water molecules will start surrounding the negatively charged chloride ion. Now the chloride ion suddenly finds itself being attracted to all these water molecules around it. The sodium ion suddenly finds itself being attracted to all these water molecules around it. And what happens? It's like a bunch of little ants acting against something that's otherwise really strong. The sodium and chloride ions drift apart from each other to be replaced by a sphere of water molecules. Each of them

Tracy: So then

John: Then sodium

Tracy: Sodium and

John: Chloride

Tracy: Chloride

John: Discipline.

Tracy: Discipline.

John: They

Tracy: They

John: Do,

Tracy: Do.

John: But

Tracy: But

John: Then

Tracy: Then

John: It's

Tracy: That's

John: Not

Tracy: Not

John: Salt

Tracy: Salt

John: Anymore.

Tracy: Anymore.

John: I guess what you have before they split.

Tracy: Salt.

John: Salt. We

Tracy: We

John: Have

Tracy: Have

John: Sodium

Tracy: Sodium

John: Ions

Tracy: Ions

John: And

Tracy: And

John: You

Tracy: You

John: Have

Tracy: Have

John: Chlorine

Tracy: Chloride

John: Ions,

Tracy: Ions.

John: Do

Tracy: Do

John: You

Tracy: You

John: Not?

Tracy: Not? Yes.

John: Yes. Yeah.

Tracy: Yes.

John: Guess

Tracy: Guess

John: What

Tracy: What

John: You

Tracy: You

John: Have

Tracy: Have

John: After

Tracy: After

John: They

Tracy: They

John: Split.

Tracy: Split.

John: Sodium

Tracy: Sodium ions and

John: Chloride.

Tracy: Chloride ions.

John: Yeah. So get this. The breaking of an ionic bond is a physical change.

Tracy: But

John: Well,

Tracy: I thought you said sodium

John: That's

Tracy: Has

John: Very

Tracy: Very

John: Different

Tracy: Different

John: Properties

Tracy: Properties than

John: Than sodium

Tracy: Sodium

John: Chloride.

Tracy: Chloride

John: The

Tracy: And

John: S

Tracy: Chloride

John: Sodium sodium

Tracy: Has.

John: Atoms are different from sodium ions for sure. A sodium atom has eleven protons, eleven electrons, eight. It's

Tracy: It's

John: Neutral.

Tracy: Neutral.

John: It has no net charge whatsoever. You remove an electron from that sodium. So it has eleven protons and ten electrons. You now the sodium **I I I**

Tracy: I am

John: Ion

Tracy: loved.

John: Sodium ion is not a sodium atom. They sound alike but they are completely different substances going from a sodium atom to sodium ion. Yes. That is a chemical change. But I'm telling you here, going from us sodium ion to a sodium ion, that that's no chemical change at all.

Tracy: Ok. I see.

John: So

Tracy: It's.

John: When you have salt and you throw into the water, notice, you still have the salt. It just is that the sodium and chloride ions are now no longer within a crystal in structure. Those sodium chloride ions are now distributed throughout the water.

Tracy: To

John: We say

Tracy: Say

John: That

Tracy: That

John: The

Tracy: The

John: Sodium

Tracy: Sodium

John: Chloride

Tracy: Chloride

John: Has

Tracy: Has dissolved.

John: Dissolved

Tracy: Okay.

John: In the water,

Tracy: But.

John: But notice you still have sodium chloride. If you were to evaporate the water, you'd see the salt crystals start to reform.

Tracy: And as the as the water evaporated, the sodium and the chloride would find

John: Each

Tracy: Each other

John: Other.

Tracy: Again. And then they would

John: Exactly.

Tracy: Form another ionic

John: Ionic

Tracy: Bond.

John: Bond. Exactly. Excellent.

Tracy: Hence

John: The

Tracy: The crystals.

John: Crystals.

Tracy: Okay.

John: Ok. So we've covered dipole, dipole attractions. Good example is the attraction between two water molecules. Each water molecule having a dipole, right? Then the second example you looked out was what we call the ion dipole attraction. It's the attraction between an iron and a dipole. An example would be sodium ion in a water molecule. The city mile would be attracted to the oxygen side of a water molecule because the oxygen side of the water molecule is slightly negative in the city on my own. It's pretty darn positive. Opposites attract. Was that

Tracy: Ok,

John: Ok

Tracy: I'm with

John: With you

Tracy: You

John: There,

Tracy: There actually

John: Actually, for

Tracy: For

John: Real

Tracy: To

John: And

Tracy: Talk

John: Talk about.

Tracy: About OK.

John: That was

Tracy: What's

John: To.

Tracy: Next?

John: The third one to talk about is called the dipole induced dipole attraction. Go to the page.

Tracy: Hyppolite.

John: Dipole induced dipole

Tracy: Oh,

John: Attractions.

Tracy: There it is. Okay. Yeah.

John: Yeah. You know, the dipole is.

Tracy: A dipole is when part of the molecule is slightly positive and part of the molecule is slightly negative.

John: Bingo. Great. Now let's talk about an induced dipole for water, that dipole is a permanent situation because that's just the nature of hydrogen and oxygen atoms. Let's look at an otherwise non-polar molecule. Ficklin Anyone?

Tracy: Oxygen.

John: Oxygen,

Tracy: Oxygen,

John: Oxygen

Tracy: Action

John: Molecule,

Tracy: Molecule,

John: O2.

Tracy: O2.

John: Right. Okay. There's no polarity to an oxygen molecule, which is why it's a gas at room temperature. It's just two oxygen and I'm stuck together by a double covalent bond. It's non polar. You don't have electrons congregating to one side permanently

Tracy: So the electrons

John: Or

Tracy: Are

John: Distributed

Tracy: Distributed

John: Equally.

Tracy: Equally all over

John: Let's

Tracy: Those

John: Say

Tracy: Two

John: Let's say evenly.

Tracy: Oxygen molecules

John: Yeah,

Tracy: Evenly.

John: Equally evenly around the whole molecule. That's right. One side's not slightly positive. One side thought not slightly negative. It's non-polar. Right. But bear in mind the electrons and he's evil entities that are whizzing around at really high speeds. What do you suppose might happen if a water molecule came along, say, with the oxygen side facing that oxygen molecule? Remember, the oxygen side is negative, slightly negative. How would the electrons in the oxygen molecule feel about that?

Tracy: They would want to get away. Because the electrons are negative.

John: Negative because like signs repel. So here you have an oxygen molecule minding its own business. Totally non-polar. Then along comes a water molecule where the oxygen side facing it. It's going to disturb the situation. The negative side of that water molecule is going to literally push those electrons within the action molecule away. Such that one side of the oxygen molecule has a buildup of negative charge. Why? Because the electrons are running away from that water molecule. And while that's happened, while one side of that oxygen molecule has become slightly negative, the other side has become slightly positive. The electrons are now no longer distributed evenly. We has induced a dipole in the oxygen molecule, a it's a dipole. It's not there normally. But we induced it

Tracy: Through

John: Through the

Tracy: The

John: Presence

Tracy: Presence

John: Of

Tracy: Of

John: Another

Tracy: Another molecule

John: Molecule that

Tracy: That

John: Has

Tracy: Has

John: It.

Tracy: A dipole.

John: Yeah, yeah. So you know what? You're going to have an attraction now between the permanent dipole of water in that temporary dipole of the oxygen. And guess what we call that attraction.

Tracy: Dipole induced dipole

John: Yeah,

Tracy: Attraction.

John: Sometimes I like to call it a dipole temporary dipole attraction, but the the standard they the word induced induced dipole. Got that?

Tracy: Yeah,

John: Yeah,

Tracy: That

John: That sounds

Tracy: Sounds

John: Pretty

Tracy: Pretty

John: Easy.

Tracy: Easy.

John: Yeah. But a little bit more complicated than dipole. Dipole. Right.

Tracy: Right. Because

John: Yeah.

Tracy: It's a

John: It's

Tracy: It's

John: A

Tracy: A

John: Situation.

Tracy: Situation also

John: It's

Tracy: Telling

John: This is

Tracy: A

John: A

Tracy: Story

John: Story

Tracy: About.

John: Behind it. OK. If you understand that, if

Tracy: If

John: You

Tracy: You

John: Really

Tracy: Really

John: Do,

Tracy: Do

John: You'll be

Tracy: Be

John: Able

Tracy: Able

John: To

Tracy: To.

John: Answer this scenario. You're ready.

Tracy: Let's try it.

John: Once

Tracy: Once

John: Upon

Tracy: Upon

John: A

Tracy: A time.

John: Time you had this oxygen molecule minding its own business. The electrons were distributed evenly around that oxygen molecule. O2. And it was thus non-polar. Then along came a water molecule. From the hydrogen side, the hydrogen side of that water molecule is slightly positive in the water molecule approached with the hydrogen side facing that oxygen molecule, minding its own business. What happens next? Okay,

Tracy: Okay,

John: Listeners,

Tracy: Listeners,

John: What

Tracy: What

John: Do

Tracy: Do

John: You

Tracy: You

John: Think

Tracy: Think? Let's think about

John: This.

Tracy: This.

John: All right, let's do the next one. We want to move along here. Right. The fourth one is called. The induced dipole induced dipole attraction in the story gets even a little bit more complicated. I like to use the analogy of people on a boat,

Tracy: Ok, we're going on a boat

John: So

Tracy: Ride.

John: It's like it's a whale watching tour. Yeah. Everybody's on the boat and they're distributed evenly. And so the boat is even keel. All right.

Tracy: Ok. Everybody's spread out looking for the whales.

John: Suddenly there's a whale on one side. What happens?

Tracy: Everybody's going to run over to the port.

John: They run over to the port side and is the boat even keel now?

Tracy: There's a lot of people

John: Yes,

Tracy: And it's

John: This

Tracy: A small

John: Moment,

Tracy: Boat.

John: Well, electrons are like people in that boat. They're moving about randomly. Right. But even without a whale coming around, what can happen is by random chance with out the whale. You'll find the electrons congregated to one side.

Tracy: Really?

John: Yeah,

Tracy: Yeah,

John: Just

Tracy: Just

John: For

Tracy: For

John: A

Tracy: A

John: Moment.

Tracy: Moment.

John: But then it's gone. And then a moment later, they're congregated to the other side. It's a probability thing. If you have a bunch of electrons like that, they're moving about randomly. That means they're going to be moments in which they're congregated to one side, but then another moment they're congregated to the opposite side. And if you look at it on average, over time, they're distributed evenly. Yeah, but for any one particular moment, take a quick snapshot. You might find the electrons congregated to one side and the boat's not going to be even keeled. And as they're congregated to that one side where they are because they're electrons is going to be slightly negative and where they're not, it's gonna be slightly positive. Here you have what's called a spontaneous dipole or sometimes is called a temporary dipole a

Tracy: Okay.

John: Now taking out a mini atom.

Tracy: Aluminum.

John: I don't. OK.

Tracy: Ok, good.

John: Good

Tracy: I had.

John: Idea. OK. I dine is a non-polar, Adam actually put him together with another idea. And you have diatonic, I-9s. I too. It's a non-polar molecule. Right. And within an iodine molecule, you'll find the electrons are distributed evenly. But what can happen is the electrons might congregate to one side just for a moment. How might a neighboring iodine molecule feel about that?

Tracy: There there is electrons are going to get pushed around as well.

John: So a spontaneous, momentary temporary dipole and one iodine molecule. It's going to have an effect on any neighboring iodine molecules. Right. And that will induce a dipole in that neighboring iodine molecule. So we have what you might call a spontaneous dipole induced dipole attraction. But when it comes to it, it's hard to tell who affected whom was the first molecule that affected the second or as a second? It did the first. And you know what? The history doesn't matter. And that's why we just simply call it an induced dipole induced dipole attraction. It's a force of attraction that occurs between otherwise non-polar molecules

Tracy: Some sort of

John: Theoretical.

Tracy: Theoretical.

John: But it's exactly why iodide a non-polar material is a solid at room temperature. It's a solid.

Tracy: Huh.

John: I dine, molecules are sticky. Get this, they're even stickier than water.

Tracy: Really?

John: Water

Tracy: What is

John: Is

Tracy: It?

John: A liquid at room temperature. Iodine is a solid, but it's non-polar. Yeah, it's non-polar that those induced dipole induced dipole interactions, they can add up. You know how Velcro one one little hook of Velcro isn't very strong.

Tracy: Yeah, but

John: But

Tracy: If

John: If

Tracy: You

John: You

Tracy: Have

John: Have

Tracy: A

John: A million

Tracy: Billion

John: Hooks,

Tracy: Hooks,

John: Be

Tracy: Be

John: Hard

Tracy: Hard

John: To

Tracy: To

John: Get

Tracy: Get

John: Into.

Tracy: It apart. Yeah.

John: Yeah. Yeah. So induced dipole induced dipoles can add up. This brings up another aspect of induced dipole induced dipole interactions.

Tracy: Your actions, WhatsApp,

John: The

Tracy: The

John: Size

Tracy: Size

John: Of

Tracy: Of the

John: The molecule

Tracy: Molecule.

John: Makes a difference. I'd-I'd turns out to be a fairly large atom is to say it's like a boat with a large deck. It means the probability of electrons being to one side is little bit better. Then if you have a really small atom such as fluorine with an fluorine, the atom is so small that kongregate electrons to one side. It's just not practical because remember, electrons repel electrons and if they're in really close proximity which they are in a really small atom, they ain't gonna do that.

Tracy: They

John: They

Tracy: Also

John: Also

Tracy: Move really,

John: Really, really,

Tracy: Really,

John: Really

Tracy: Really fast.

John: Well. They move.

Tracy: I mean, it's.

John: They move fast. And both the small and the large atoms

Tracy: Then if a smaller atom, they have less

John: Have less

Tracy: They

John: Area

Tracy: Have less

John: To

Tracy: Area to

John: Move.

Tracy: Move in.

John: Yes,

Tracy: Yes.

John: They have less area to move in. And so that to tip to get them congregated to one side is much more difficult in a good way to think of it as like this. dros a small circle. Go ahead.

Tracy: Ok.

John: Okay.

Tracy: Ok.

John: Okay. That's

Tracy: That's good.

John: Good. Right. I see you have it's about half an inch in diameter.

Tracy: But he could

John: Now

Tracy: Now

John: Draw

Tracy: Draw

John: Another

Tracy: Another

John: Circle.

Tracy: Circle,

John: Make

Tracy: Make

John: It

Tracy: It

John: Large.

Tracy: Large. Okay.

John: Okay. Okay.

Tracy: Okay.

John: That's

Tracy: That's

John: Like

Tracy: Like

John: Three

Tracy: Three

John: Inches

Tracy: Inches

John: In

Tracy: In

John: Diameter.

Tracy: Diameter.

John: Right.

Tracy: Right.

John: So

Tracy: So

John: We

Tracy: We

John: Have

Tracy: Have

John: Drawn

Tracy: Drawn

John: Two

Tracy: Two

John: Circles,

Tracy: Circles

John: Have

Tracy: Every

John: We not?

Tracy: Night. Mm hmm.

John: Now,

Tracy: Now.

John: I want you to put electrons in there. A dot, you know, just specs with your pencil, put 20 dots in the small circle and 20 dots in the large circle. Go ahead. OK. Notice that in the small circle, all those dots are really bunched together.

Tracy: Together.

John: Notice in the large circle, those dots have more space between them. Look

Tracy: Look at

John: At the

Tracy: The

John: Average

Tracy: Average.

John: Distance between the dots. It's greater in

Tracy: In

John: The

Tracy: The

John: Larger

Tracy: Larger

John: Circle.

Tracy: Circle,

John: In

Tracy: In

John: The

Tracy: The

John: Larger

Tracy: Larger

John: Circle.

Tracy: Circle.

John: I dine is a larger atom, which means when they do congregate to one side, there's still not that close to each other.

Tracy: All

John: That's

Tracy: Right.

John: What

Tracy: What

John: Makes

Tracy: Makes

John: It

Tracy: It

John: Possible

Tracy: Possible

John: For a larger

Tracy: I see

John: Atom,

Tracy: A

John: A

Tracy: Small

John: Small atom

Tracy: Item

John: Like

Tracy: Like.

John: Fluorine induced, dipole induced dipoles ain't nothing. And that is why. Paid for it. Florian is used in Teflon. The nonstick surface. With Teflon, you have a non-polar molecule, so there's no dipoles, but because you're using fluorine atoms within that polymer, you don't even get induced dipoles. That's how it is that Teflon has a nonstick surface.

Tracy: Surface cool.

John: Q.e.d.. That's

Tracy: That's

John: It.

Tracy: It. That's

John: We

Tracy: Very

John: Have

Tracy: Cool.

John: We

Tracy: We

John: Have

Tracy: Have

John: Four

Tracy: For.

John: Interactions the iron dipole, dipole, dipole,

Tracy: In D

John: Dipole,

Tracy: Dipole,

John: The dipole

Tracy: Dipole

John: Induced

Tracy: Induced

John: Dipole,

Tracy: Dipole, dipole

John: Lindy's

Tracy: Induced

John: Dipole.

Tracy: Dipole

John: Yeah. And

Tracy: In

John: The

Tracy: The

John: Last

Tracy: Last

John: One

Tracy: One,

John: Induced.

Tracy: Induced

John: Dipole

Tracy: Dipole

John: Induced.

Tracy: Induced dipole.

John: Great.

Tracy: Great.

John: Excellent.

Tracy: Excellent.

John: One, two, three, four questions.

Tracy: Ok, what's next?

John: What's next are a bunch of terms. Oh, my goodness, look at all these terms. Let's just do a quick review of these terms. All right. Let me ask you.

Tracy: I haven't read this chapter yet.

John: You

Tracy: You

John: Did

Tracy: Did.

John: This

Tracy: Okay.

John: While ago, you remember it all.

Tracy: All right.

John: Solvent.

Tracy: Solvent think when you put the water is the solvent when you add salt to it?

John: Okay, save some salt and you add some water to it. You'd recognize the water as the solvent. Yes. Why?

Tracy: Because it's what the salt dissolves and separates into.

John: Ok. That's pretty good. We can add to that the solvent you typically have more of.

Tracy: I was just picturing when we you know, when you trying to get some group off and you just take a little bit of

John: Wd

Tracy: Ethanol

John: 40.

Tracy: Or look,

John: No

Tracy: You know, it is

John: Rubbing alcohol,

Tracy: Rubbing

John: Rubbing alcohol

Tracy: Alcohol

John: Or

Tracy: Or what

John: What do

Tracy: Do

John: We

Tracy: We use

John: See on

Tracy: On

John: The

Tracy: The

John: Floor,

Tracy: Floor

John: Water?

Tracy: Water.

John: No,

Tracy: No,

John: That

Tracy: That

John: Horrible,

Tracy: Horrible

John: Simple

Tracy: Simple green,

John: Green.

Tracy: No methanol, no

John: Ethanol.

Tracy: Ethanol knows in the cans. When we did the tile, when we took off that

John: Who acetone.

Tracy: That's

John: Ok.

Tracy: Ok. Acetone,

John: That

Tracy: That

John: Was

Tracy: Was

John: The

Tracy: The solvent.

John: Solvent, the song. Is that which dissolves in the solvent and quantitatively you typically have

Tracy: Less

John: Less.

Tracy: Less.

John: Yeah. It's a question of which is more typically the solvent is more than the solitude. When they come together and dissolve, they form a single homogenous mixture called a sole sole

Tracy: Solution,

John: Solution.

Tracy: Lucian.

John: And that process is called desire. Desire

Tracy: Dissolving.

John: Dissolving. Excellent.

Tracy: Yeah, but the big thing that you just said was homogenous mixture.

John: That means if you're to take a microscope and look at it in any different part, you see it's the same thing, right? You get a stirred up saturated solution. What's that?

Tracy: That means you can't dissolve any more solid

John: So

Tracy: Into

John: There's a

Tracy: That

John: Solution.

Tracy: Solution.

John: So there's a limit to the amount of solitude that can dissolve in a solvent.

Tracy: You know, there's a limit, but it's based on a couple of things.

John: Have you ever made some sugar syrup? Oh,

Tracy: Oh, yeah.

John: Yeah.

Tracy: Not as much as you do.

John: You had some sugar to a pan, then you add water to it and you have a lot of sugar and you're adding a little bit of water. A lot of sugar, but a little bit of water. Which is the solvent.

Tracy: The

John: Sugar.

Tracy: Sugar.

John: Turns out it's the water. How can that be? Remember, we said it's that. Would she have most of

Tracy: Oh, yeah, that's

John: That?

Tracy: What I meant.

John: Okay, so

Tracy: So.

John: Here you need to think in terms of how many molecules. When we talk about amount, not mass, but number of molecules, a water molecules we find are way smaller than sugar molecules as sugar molecules as bird fruit. It's a big old molecule of with tens and tens of atoms all stuck together. Water molecules really tiny. So if you had this the same volume of each, you'd have like 100 times more water molecules. Right. And all those little water molecules surround the sugar molecules separating the sugar molecules from each other. Sound familiar? That was with the ion dipole thing. Dissolving

Tracy: Dissolving

John: Salt

Tracy: Salt

John: And

Tracy: And

John: Water.

Tracy: Water.

John: Dissolving sugar and water is very similar. The water molecules being so tiny get in between the big sugar molecules and they separate them from themselves. So where before you have a large crystal of sugar molecules all piled on top of each other, nice order after the sugar molecules are distributed evenly throughout the water. We call that process dissolving. We are dissolving the sugar in the water, using the water to dissolve the sugar. Now we're talking about here's what's happening at the molecular level. The water molecules are interrupting the interaction between sugar molecules. There's no chemical change going on here before you have sugar and water, after you have sugar and water. What's different is that what you now have is a mixture and if you stirred up well enough, you'll have a homogeneous mixture with a microscope. You can't distinguish one part of the solution from another. Yeah, we call that a solution. In this case, it's a liquid solution. So way back to the term saturated solution, it turns out water has a limit in terms of how many sugar molecules that can separate from each other. You keep adding your sugar. Eventually you'll get to the point you don't have enough water molecules to do it. And when that happens, the sugar just stares at you and laughs, says, you think I'm going to separate from my neighbor. You're only three water molecules. I need 100 molecules in order for you to separate me for my neighbor. So it doesn't happen. And you have a saturated solution where if you were to add more sugar, it wouldn't dissolve. You've reached the limit of solubility. Whoops. There's another term solubility to find that

Tracy: How

John: How easily

Tracy: Easily

John: It

Tracy: It

John: Can.

Tracy: Can dissolve?

John: Damn. Excellent. Love

Tracy: Look.

John: It. Yeah. They have the ability of a soul you to dissolve. Is it soluble? That means it will dissolve. Well, is it not soluble? That means it won't dissolve well.

Tracy: I

John: And

Tracy: Can't

John: Again,

Tracy: Get

John: We're talking about interactions

Tracy: Interactions

John: Between

Tracy: Between

John: Molecules,

Tracy: Molecules,

John: Aren't

Tracy: Aren't

John: We?

Tracy: We?

John: In

Tracy: And

John: The

Tracy: The

John: General

Tracy: General

John: Trend

Tracy: Trend

John: Is

Tracy: Is

John: Stickiness,

Tracy: Stickiness.

John: Stickiness,

Tracy: Stick.

John: And the stronger the interaction between the solid

Tracy: Sold

John: And solvent

Tracy: It? Yeah. Then it.

John: Dissolve the

Tracy: Next

John: Section

Tracy: Section

John: Concentration.

Tracy: Concentration,

John: More terms,

Tracy: An unsaturated

John: The saturated solution,

Tracy: Solution,

John: Unsaturated

Tracy: Unsaturated

John: Solution.

Tracy: Solution,

John: That's

Tracy: That's

John: What

Tracy: What

John: It's

Tracy: It's

John: Like

Tracy: Like

John: Before

Tracy: Before

John: You

Tracy: You

John: Hit

Tracy: Hit

John: The

Tracy: The

John: Saturation

Tracy: Saturation

John: Point.

Tracy: Point. You can

John: Keep

Tracy: Keep

John: Adding

Tracy: Adding

John: Sugar

Tracy: Sugar and

John: And it

Tracy: It

John: Will

Tracy: Will

John: Keep

Tracy: Keep

John: Dissolving.

Tracy: Dissolving.

John: Correct.

Tracy: Correct. Okay.

John: Okay. Excellent.

Tracy: Excellent.

John: All right. More terms here we have the term concentration.

Tracy: Is that what you're thinking really, really hard?

John: Equation right here says amount of Sol you divided by the amount of solution.

Tracy: So

John: So that

Tracy: That

John: Gives

Tracy: Gives

John: You

Tracy: You the

John: The

Tracy: Concentration?

John: Concentration? Yes,

Tracy: Yes.

John: Say you

Tracy: You

John: Had

Tracy: Had.

John: 100 grams of sugar in 200 grams of water. You could calculate your concentration. It would be 100 divided by 200 grams per gram.

Tracy: 1 1/2.

John: What's

Tracy: What's

John: Important

Tracy: Important?

John: Is that

Tracy: Twenty two

John: What

Tracy: Point

John: What

Tracy: Five.

John: The idea

Tracy: It

John: Is

Tracy: Is.

John: The amount of you divided by the amount of solution. So

Tracy: Let's

John: It's

Tracy: Get

John: A fraction

Tracy: Action

John: Now,

Tracy: Now twice

John: Twice as

Tracy: As

John: Much.

Tracy: Much.

John: Stop that. So notice the units here. It's real important. We just talked about the tracers trying to figure out is 100 grams of sugar divided by 200 grams of water. Right.

That's a unit of mass divided by a unit of mass. Fine. Go ahead and do that. That that's good. But the convention is to talk about the amount of solitude in terms of its mass and to talk about the amount of solution in terms of its volume and note carefully. We're talking solution, not solvent. So typically concentration is given as the amount of solid youit divided by the amount of solution, not solvent solution. Now what does that make a difference? Consider you've got 100 milliliters of water, right? Okay. Now you're going to add some sugar to it. Do you still have 100 milliliters? Now,

Tracy: Ok.

John: As you add the sugar to the water, you're going to increase the total volume. You may have 100 milliliters of water, but after you add the sugar, the volume of solution, which is a combination of the water and the sugar, it's going to be greater than 100 milliliters. So we're going to be really careful here by convention. When we talk about concentration, we're talking about the amount of Saúl UIT divided by the volume of solution, which is the combination of the salut and the salt. Then it. If you're kind of drifting off with all these terms we've been presenting to you, that's fine. It's nothing like some good alpha waves. But I'm sorry, I'm gonna have to wake you up right now. The mall, the mall, the mall, the mall. The mall. Okay. Do I have your attention,

Tracy: Cheesey.

John: Tracy? Yeah.

Tracy: Yep, you got my attention

John: Okay. We're

Tracy: About

John: About

Tracy: The

John: To define

Tracy: Mind.

John: The mall. Different chemistry curricula will introduce it at different places. I like introducing it here when we're talking about concentration. The mall

Tracy: More

John: Is

Tracy: Than.

John: The number and a common unit of concentration is the mole per liter. Leader you'll get that's that's a volume, right? But more what is a mole? A mole is a count of molecules. I

Tracy: Account

John: Count.

Tracy: Of molecules.

John: Yes. We're not talking about the mass of the molecules here, we're talking about the number of them you have.

Tracy: Because before

John: Before his.

Tracy: You said that you'll have a lot more water molecules than sugar molecules because they're different

John: Chemists,

Tracy: Sizes

John: Chemists are

Tracy: To.

John: Typically interested in the number of molecules that are there.

Tracy: When they're interacting with another number

John: Mm

Tracy: Of molecules

John: Hmm.

Tracy: Of

John: Well,

Tracy: A different

John: And also

Tracy: Kind.

John: When we do chemical reactions, we'll talk about this later, how it is you need to take so many of these molecules, plus so many of those molecules to come up with so many of these new molecules. We're focused here on the number of molecules that we've got. Why is that? Because different molecules have different masses and it's quite useful to talk about them in terms of the number. Because if you have five of this and five of that and these it keep track of. But whatever. Here we go. The mole is a number. And it's our honor to introduce you to this term if you haven't heard it already. Okay, let's begin. You're ready.

Tracy: Ready? Ready.

John: Ready? What's

Tracy: What's

John: A

Tracy: A

John: Dozen?

Tracy: Dozen 215th?

John: So a dozen is another term we use to describe Twelfth Night.

Tracy: Right. Mm hmm.

John: What's

Tracy: What's

John: A

Tracy: A

John: Pair?

Tracy: Pair?

John: To

Tracy: Two of

John: Something?

Tracy: Something?

John: Yeah,

Tracy: Yep.

John: A pair of shoes. I mean, you have two shoes, okay. What's a rim?

Tracy: A big thing

John: Paper.

Tracy: Of paper. Yes.

John: Yeah, five

Tracy: Five

John: Hundred,

Tracy: Hundred. Five

John: Yeah,

Tracy: Hundred.

John: Yeah. Five

Tracy: Five

John: Hundred

Tracy: Hundred.

John: When you have five hundred sheets of paper that's called one ream.

Tracy: Ok.

John: Right. I'm a mole. Likewise is a number like a dozen a pair ream. Right. But a mole is much bigger than twelve and actually much bigger than five hundred. A mole is equal to 6.0. Two times tend to the twenty third.

Tracy: Six point oh, two times ten to the twenty third

John: Twenty

Tracy: One D

John: Third.

Tracy: Third

John: That's

Tracy: Twenty

John: Talk.

Tracy: Third.

John: That's twenty three zeros like a trillion, trillion, trillion, trillion, surely. It's huge.

Tracy: That's a lot.

John: Why

Tracy: Why

John: Is

Tracy: Is

John: It

Tracy: It

John: So

Tracy: So

John: Huge?

Tracy: Huge? Yeah,

John: Why

Tracy: Why

John: Would

Tracy: Would

John: You

Tracy: You

John: Want

Tracy: Want

John: To

Tracy: To

John: Know

Tracy: Know

John: So

Tracy: So

John: Many?

Tracy: Many?

John: Guest

Tracy: Why wouldn't

John: Host?

Tracy: You just do twelve?

John: Twelve. Guess

Tracy: Gets

John: How

Tracy: A

John: Big

Tracy: Big

John: Molecules

Tracy: Molecules.

John: Are

Tracy: They're really

John: Breathing?

Tracy: Not that

John: Not

Tracy: Big.

John: Really, really, really, really, really, really, really, really, really, really, really, really, really,

Tracy: Really,

John: Really,

Tracy: Really?

John: Really,

Tracy: Okay,

John: Really

Tracy: John, come

John: Small.

Tracy: On, get it. They're

John: They're really

Tracy: Really

John: Small.

Tracy: Small, really

John: Really small.

Tracy: Small,

John: Really

Tracy: Really

John: Small.

Tracy: Small.

John: Yeah. If you have a tablespoon of water it guess how many water molecules you have in there? A lot or a little.

Tracy: Well, a lot

John: More

Tracy: More

John: Than

Tracy: Than 500.

John: 500 yes,

Tracy: Yes, it.

John: In a tablespoon of water. You've got about 6.0, two times 10 to the 23rd of them.

Tracy: Even more in

John: You

Tracy: About

John: Have one

Tracy: A tablespoon.

John: More.

Tracy: Really?

John: It

Tracy: Just.

John: Just went technically 18 milliliters in 18 milliliters of water. You've got 6.0 two times tend to the twenty third water molecules.

Tracy: How much?

John: 6.0 to times tend to the 23rd

Tracy: In

John: And

Tracy: What

John: What.

Tracy: And how?

John: And

Tracy: What

John: Amount

Tracy: Amount? Volume in

John: In 18

Tracy: 80mm

John: Milliliters.

Tracy: 18.

John: Yeah,

Tracy: Mm,

John: But a couple tablespoons.

Tracy: Well.

John: Now 6.2 times 10 the 23rd is really difficult number to wrap one's mind around. And we had a snowstorm here and where we live and we got like good 21 inches of snow. Yes,

Tracy: Yes.

John: It was insane.

Tracy: Yes,

John: Absolutely

Tracy: Absolutely,

John: Insane.

Tracy: And save.

John: It got us wondering how many snowflakes were in that snowstorm. That's

Tracy: That's

John: What

Tracy: What

John: We

Tracy: We

John: Did.

Tracy: Did when we were snowed in.

John: It's

Tracy: We started

John: Started

Tracy: Calculating

John: Back

Tracy: Back

John: Of

Tracy: The

John: The envelope

Tracy: Could there

John: Calculations.

Tracy: Possibly be one more of

John: Snowflake

Tracy: Snowflakes.

John: In that snowstorm.

Tracy: And John had a very interesting discovery. Fascinating

John: I

Tracy: Discovery.

John: I. I thought it was utterly amazing. We went out and we grabbed a teaspoon of snowflakes and we put them under our magnifying glass and we took a rough estimate account to the number of snowflakes that were in

Tracy: A

John: That teaspoon.

Tracy: Teaspoon.

John: Right. Yeah. And from that day, we estimated the number of snowflakes in a cubic inch. And from that, we estimated the number of snowflakes in our yard, which isn't that big.

Tracy: Eg.

John: And from that we estimated the number of snowflakes that were through our whole town.

Tracy: From

John: And from

Tracy: The.

John: That the whole state, it was a big snowstorm.

Tracy: Store big state,

John: Several

Tracy: Several

John: States,

Tracy: States.

John: In

Tracy: In

John: Fact.

Tracy: Fact,

John: And

Tracy: We

John: We found

Tracy: Found.

John: That it was a tiny, tiny, tiny fraction of the mall.

Tracy: It

John: It was

Tracy: Was

John: Not

Tracy: Not

John: Even

Tracy: Even

John: One.

Tracy: One more.

John: It

Tracy: It

John: Wasn't

Tracy: Wasn't

John: One

Tracy: One.

John: More.

Tracy: Twenty one inches covering hundreds of square

John: Square miles.

Tracy: Miles. Square

John: Yeah.

Tracy: Miles

John: It's not one mole

Tracy: Of

John: Of

Tracy: Snowflakes.

John: Snowflakes you would need to cover the entire planet and you still wouldn't have one mole of snowflakes. You would need six earths of snow. I think we calculated one foot deep to have one mole of snowflakes. Imagine six earths covered with one foot of snow. Count all those snowflakes, you've got yourself one more of them. It is an astronomically large number.

Tracy: A

John: Very

Tracy: Very

John: Big

Tracy: Big

John: Number.

Tracy: Number.

John: And the reason we use an astronomically large number is because water molecules, not snowflakes, are astronomically small. That within 18 milliliters of liquid water, you've got 6.0 two times ten to twenty third water molecules.

Tracy: So

John: It's

Tracy: It's really

John: Really

Tracy: An

John: Inconceivably

Tracy: Inconceivably

John: Large.

Tracy: Large

John: Yeah,

Tracy: Number.

John: It's

Tracy: It's

John: It's

Tracy: It's

John: It's

Tracy: It's

John: Just

Tracy: Just

John: It's

Tracy: It's

John: Just

Tracy: Just

John: Way

Tracy: Way out

John: Out

Tracy: There.

John: There. Yeah,

Tracy: Wow.

John: But if you had 342 grams of sugar.

Tracy: Yeah.

John: Guess

Tracy: Guess

John: What?

Tracy: What? Is that one more? Three

John: That's

Tracy: Hundred and

John: 42

Tracy: Forty two

John: Grams.

Tracy: Grams of sugar

John: Sugar equals

Tracy: Equals.

John: Six. Put it two times tense. The 23rd sugar molecules, sugar molecules are small to notice.

Tracy: Notice you

John: You

Tracy: Need

John: Need

Tracy: 340.

John: 342 grams of sugar to have one more. But waters cause it's much smaller. You only need 18 grams to have one

Tracy: 18

John: Meal

Tracy: Mm oh,

John: Which

Tracy: 18

John: Gram

Tracy: Grams.

John: Which is

Tracy: Oh,

John: Equal

Tracy: Right.

John: To 80 milliliters.

Tracy: Because of its

John: Density

Tracy: Density

John: Is

Tracy: Of density.

John: One. You don't do that in her head. Great. So we talk about concentration. We want to talk about the number of molecules that have dissolved and we use the unit of the mall for convenience. So if you take 342 grams of sugar,

Tracy: One

John: One more

Tracy: More.

John: Dissolve it so that you make a solution. That's one leader in volume. The concentration will be

Tracy: One

John: One more

Tracy: More

John: Per

Tracy: Per

John: Liter.

Tracy: Liter.

John: Excellent. One more per liter. Okay. That's an introduction. That's a decent introduction.

Tracy: Very

John: You

Tracy: You

John: Kind

Tracy: Kind

John: Of

Tracy: Of

John: Went

Tracy: Went

John: On

Tracy: On

John: About

Tracy: About

John: The

Tracy: The.

John: Mole itself, but you'll find calculations you can practice those concepts with in the textbook at the Holmer practice sessions at Conceptual Academy and also from your instructor. Awesome. Right. Moving right along. Solubility in temperature is an interesting concept here. It's that when you increase the temperature, you might expect that the solubility also increases. And that's commonly the case as with sugar and water. You can think of it this way as you increase the temperature, you're making those water molecules more active or kinetically charge.

Tracy: Urged

John: That's

Tracy: Moving

John: Moving.

Tracy: Faster,

John: Moving faster.

Tracy: Faster.

John: Yeah. And it can pow, pow, pow against that crystal structure much more effectively. That's the case when you tried to dissolve sugar and water. You know, sugar dissolves better in warm water than it doesn't cold water. Right. But here's where it gets interesting. You try to dissolve salt, sodium chloride in water. The temperature makes little difference. Interesting.

Tracy: Interesting.

John: Yeah,

Tracy: Yeah.

John: Because the attractions that the islands have from themselves is just so relative to the attraction between water molecules themselves. It gets complicated actually. So

Tracy: At

John: The

Tracy: Is

John: Sugar

Tracy: Sugar. Have

John: Ionic

Tracy: Ionic

John: Bond

Tracy: Bonds.

John: Sugar is a covalent compound.

Tracy: It's

John: It's a covalent molecule.

Tracy: Okay. It's

John: It is very

Tracy: Very.

John: Polar. I dare say. Notice what phase sugar is in. At room temperature.

Tracy: Solid,

John: Solid. Solid.

Tracy: Solid.

John: Yeah. Notice what phase water is in at room temperature.

Tracy: Temperature liquid, yeah.

John: Yeah. So sugar is a solid at room temperature. It's polar. That tells us the attractions between separate sugar molecules is huge. They stick together like crazy. Now that's. You're not learning anything new here. When we say that sugar is sticky.

Tracy: Keith,

John: Right.

Tracy: Right.

John: Right.

Tracy: All right.

John: Hey,

Tracy: Hey,

John: Add

Tracy: Add

John: A

Tracy: A

John: Little

Tracy: Little

John: Water

Tracy: Water

John: And

Tracy: And

John: You

Tracy: You

John: Know,

Tracy: Know,

John: You

Tracy: You

John: Have

Tracy: Have

John: Water,

Tracy: Water

John: Sticky

Tracy: Sources,

John: Sugars

Tracy: You're going to get

John: To get us

Tracy: All

John: All.

Tracy: Over

John: Dickie.

Tracy: You.

John: Yeah.

Tracy: Yeah, yeah.

John: Ok.

Tracy: Ok,

John: So,

Tracy: So sugar,

John: Sure, sugar

Tracy: Sugar

John: Molecules,

Tracy: Molecules.

John: They are attracted to sugar molecules. And that makes it a solid at room temperature.

Tracy: All right. There's a cool picture here where you're showing a dish that has acetone, nail polish

John: Over.

Tracy: Remover in it, and then you have a Styrofoam

John: Cutting

Tracy: Cup in

John: Their

Tracy: There.

John: Military?

Tracy: It's

John: Nothing.

Tracy: Melting.

John: No, it's not.

Tracy: All

John: Oh,

Tracy: Right.

John: So.

Tracy: So either way, to save a weird question, is that one way to get rid of Styrofoam because it's something that doesn't

John: Decompose.

Tracy: Decompose?

John: Well, what you're doing is you're dissolving the Styrofoam and the acetone. You still have the Styrofoam. Once the acetone evaporates, you're going to have the remaining Styrofoam still

Tracy: Smillie.

John: There. Yeah, though no longer puffed up. It

Tracy: It

John: Would

Tracy: Would

John: Be

Tracy: Be

John: A

Tracy: A

John: Way

Tracy: Way

John: Of

Tracy: Of

John: Moving

Tracy: Moving.

John: The Styrofoam. But that would mean at the recycling plant you would need a heck of a lot of acetone,

Tracy: Ok.

John: Which

Tracy: Which

John: Is

Tracy: Is

John: Expensive

Tracy: Expensive

John: And

Tracy: And

John: The

Tracy: The

John: Fumes

Tracy: Fumes

John: Are

Tracy: Are

John: Not

Tracy: Enough.

John: Fun to breathe.

Tracy: Ok, OK. All right. But you started to say that it's not melting.

John: Oh, it's not melting. You take a Styrofoam cup, put it in a dish of acetone.

Tracy: Nail

John: Finger

Tracy: Polish remover

John: Yeah.

Tracy: And

John: And you'll

Tracy: You'll

John: Find

Tracy: Find

John: It

Tracy: It

John: Starts

Tracy: Starts

John: To

Tracy: To dissolve.

John: Dissolve. Almost

Tracy: This.

John: Looks like it's melting, but it is not melting. It's it's dissolving. Technically, you know, the solubility of Styrofoam and acetone is not that great. What you're actually looking at there is what they call slippage. Don't worry about it. It's just that that the macroscopic form is being lost for the next.

Tracy: Looks

John: Cool.

Tracy: Cool, though.

John: Yeah. Oh, here's one other thing we should talk about. We get we get. We're almost there. Solubility of gases. Remember how oxygen is non-polar? How can you get oxygen to dissolve in water?

Tracy: Sidor. OK, so we're induced dipoles

John: Dipole

Tracy: Dipole

John: And

Tracy: Induced

John: Staples

Tracy: Dipoles.

John: Excellent. It's the dipole induced dipoles that hold oxygen within water. Now those dipole induced dipoles are relatively weak, so the amount of oxygen you can dissolve in the water isn't much.

Tracy: It's

John: It's enough,

Tracy: Enough for a fish,

John: It's

Tracy: It's

John: Enough

Tracy: Enough for.

John: For fish, it's not enough for a human. You breathe the water, there's not enough oxygen in that water to pass through your lungs. That's not good. But for fish has a gill with a different biology, a lot more surface area. It's able to pluck those few oxygen molecules out that are dissolved. Is it possible for fish to drown? Of

Tracy: Of

John: Course.

Tracy: Course.

John: How so?

Tracy: So it

John: It doesn't

Tracy: Doesn't

John: Get

Tracy: Get

John: Enough

Tracy: Enough

John: Oxygen.

Tracy: Oxygen.

John: She tell you the goldfish story. OK.

Tracy: Ok.

John: It's

Tracy: It's

John: All

Tracy: All

John: Made

Tracy: Made up.

John: Up. This didn't really happen. How to kill your goldfish.

Tracy: You.

John: Just take some water and boil it and as it boils. Any oxygen that's within that water is released. You are the oxygenating the water. No, wait a second. Doesn't want to have oxygen in it. All over the place isn't water. Eighty eight point eight percent oxygen.

Tracy: But it's

John: It's

Tracy: It's

John: Bound

Tracy: Bound

John: To

Tracy: To

John: The

Tracy: The

John: Hydrogen.

Tracy: Hydrogen.

John: I'm getting confused. If water is eighty eight point eight percent oxygen, how come we can't breathe water?

Tracy: Because it's bound, it's in a covalent bond, it's not oxygen anymore.

John: Oxygen, you mean O2? You mean die atomic oxygen molecules. So we're going to be really careful with our language here when we say we breathe oxygen. We're not talking about the oxygen in the water molecule. You breathe oxygen, you're breathing O2 molecules, which is a gas at room temperature. A it's not H2O, it's O2. Now. The fish need O2 also. The oxygen binds to the hemoglobin and it runs all sorts of things and bodily functions, we need it for energy, right? We need oxygen or we die. Could open a fish. If you ever do that, you see the blood is red. Why is it red? Because of the oxygen that has it has absorbed from the water. That oxygen, though, that it's absorbing firm, the water isn't the water molecules. It doesn't break down water molecules. Water molecules stay intact because the covalent bonds between the hydrogen oxygen, hydrogen atoms are really strong, just as you can dissolve salt and water. You can also dissolve O2 in water. And as we have seen in Krayem, you'll see an air raid or bubbles, googleable bubbles. Public schools, people to that movie.

Tracy: Finding Nemo.

John: Aerating the water. It's adding oxygen molecules to the water and you have a mixture of H2O plus O2. And it's the O2 that's dissolved in the water that the fish take in to their gills. Notice they didn't say breathe. So you're boiling the water, the pot of water. And as you do that, all the oxygen that's dissolved in there, the O2 that's dissolved, then there it will come out of solution. Now put plastic wrap on top of the surface of the water. Now let it cool down. The plastic wrap is there. So oxygen from the air doesn't get back in. And as that water cools back down, there's gonna be no oxygen in there. Very little oxygen in there. Not much. You have degraded the water you have. Let's say the oxygenated the water. We have this activity we do in class or I'll ask students to pull out some paper and a pencil and draw a cartoon of deoxygenated water. A cartoon of deoxygenated water. Now, typically, a student will draw an oxygen atom leaving the H2O, but guess what? After that oxygen atom leaves the H2O, it's no longer H2O, it's no longer water. If you die, oxygenate your water by removing the oxygen. You no longer have water. You've destroyed the water. In this case, when we talk about deoxygenated water, we're talking about removing any O2 molecules that might happen to be dissolved in the water. So that after you, you remove those O2 molecules. The water's been purified. Just plain old water without. The oxygen O2, meaning we need to be careful with our use of language. A. Now

Tracy: Take

John: Take

Tracy: Your

John: Your goldfish.

Tracy: Goldfish. No. No.

John: Remove the plastic

Tracy: Plastic.

John: And all the goldfish over it and say, hey, Goldie, would you like to go for a swim?

Tracy: Swim. No.

John: What's

Tracy: What's

John: The

Tracy: The

John: Goldfish

Tracy: Goldfish

John: Going

Tracy: Going to

John: To say?

Tracy: Say? No,

John: Cause

Tracy: Because.

John: That goldfish has had chemistry. So you careful,

Tracy: Carefully.

John: Sir.

Tracy: So it saw you

John: So

Tracy: Boiling

John: You nicely

Tracy: The water

John: Take that

Tracy: That.

John: Goldfish and you put it back in the aquarium where it is air rated because you know darn well that the goldfish would drown in that room temperature water that had been boiled because there's no oxygen O2 in there for it to take in through its gills. Yeah. Fish

Tracy: Fish

John: Can

Tracy: Can

John: Drown

Tracy: Drown, which

John: In there.

Tracy: We see.

John: We

Tracy: We

John: See

Tracy: See

John: That

Tracy: That

John: Happen

Tracy: Happen

John: In

Tracy: In

John: The

Tracy: The environment. When you have

John: Algae

Tracy: Algae blooms

John: Blooms.

Tracy: And stuff like that,

John: It's

Tracy: It's what's

John: What's called

Tracy: Called

John: A

Tracy: A pilot.

John: Biological oxygen demand. The bsod. If you have a waste products within the water, you'll find that the oxygen is consumed by the algae and other micro-organisms through the decomposition process. And because the oxygen O2 is being consumed, it's no longer available for the aquatic life. The fish will drown. Right. So real

Tracy: Real

John: Important,

Tracy: Important

John: We

Tracy: To keep

John: Keep

Tracy: Her.

John: Our water systems clear of pollutants for that reason, including fertilizers for that very reason, because we know fish can drown and we now have some insight as to how so gases can dissolve in water. Absolutely. But how they dissolve in water is really a function of temperature to the higher the temperature, the less it's able to dissolve. Which explains one other interesting item. Oceans in the tropics, because the water's warm. You have a decreased solubility of O2. That means you have less oxygen in the water in tropical areas than you do in puller areas, in polar areas. The water tends to be oxygen rich white because the water is colder. And there are other reasons too, like upwelling and currents play an important role. Anything biologicals going to be complicated. I guarantee you. But it is true that with warmer waters you tend to have less oxygen. And because you have less oxygen, you tend to have less stuff growing in that water, which is how it is. Tropical waters tend to be much more turquoise blue. They're

Tracy: They're

John: Called

Tracy: Called

John: Deserts.

Tracy: Desserts.

John: Yeah, deserts. We were in Hawaii and we thought, wow, all this water is surely a lot of fish. And really relatively speaking, there aren't because it's warm. That's not good. The oxygen goes away and you're affecting the the food chain

Tracy: There's still a lot of fish

John: And

Tracy: In

John: The

Tracy: The

John: Fish

Tracy: Fish

John: To

Tracy: To

John: Make

Tracy: Make

John: It

Tracy: It,

John: Your

Tracy: But nothing

John: Your your

Tracy: Like

John: Your

Tracy: What you would

John: Vacation

Tracy: See

John: Worth

Tracy: Worth

John: It.

Tracy: It in the

John: Temperate

Tracy: Temperate

John: Areas

Tracy: Areas.

John: And. All

Tracy: All

John: Right.

Tracy: Right.

John: And

Tracy: And

John: Then

Tracy: Then

John: Then

Tracy: Then

John: There's

Tracy: There's

John: Discussions

Tracy: Discussions

John: Here

Tracy: Here

John: About

Tracy: About.

John: How soap works. There's discussions about how we purify water.

Tracy: Hard and soft water.

John: And then there's discussions of how to make fresh water out of salt water. A reverse osmosis. Maybe we should just wrap up with reverse osmosis a little bit.

Reverse osmosis is a little bit more complicated. Maybe deserves a word or two. Then we wrap it up. How you doing?

Tracy: I'm doing good.

John: Ok. Imagine a glass of water. And in that glass of water, we're going to partition it into two sides. How

Tracy: Ok.

John: Are we

Tracy: We're

John: Going

Tracy: Gonna

John: To partition

Tracy: Put.

John: It? We could put up a metal plate down the middle, down through the middle of it. So you have a left side and a right side.

Tracy: Ok.

John: But rather than the plate, we're going to use a plate that has these tiny, tiny, tiny, tiny little holes in it. So

Tracy: So

John: Tiny

Tracy: Tiny

John: That

Tracy: That.

John: Water molecules are going to actually be able to pass through it from one side of the glass to the other.

Tracy: All right.

John: Now they're really tiny so that those tiny water molecules can pass through. But

Tracy: What's

John: What were

Tracy: Really tending the holes

John: The

Tracy: In

John: Holes,

Tracy: The plate,

John: The other holes

Tracy: Holes

John: In

Tracy: In

John: The

Tracy: The.

John: Plate? Yeah,

Tracy: Ok.

John: Yeah. But on one side, we're going to start adding salt water. OK. So we just added a bunch of salt to one side of the partition. Now, it turns out the salt ions. Sodium ions and chlorine ions. They're bigger than the water molecules. And those ions are not able to pass through those tiny little holes. So while water can easily go back and forth between both sides, the ions can't. They're stuck simply because they're too big. Yeah.

Tracy: Even when they separate.

John: Well, we know we have a solution of sodium chloride ions, right, in those sodium chloride ions or just float around and note there floating around with a sphere of water molecules around each of them, which makes them even bigger. So it just is very difficult for those sodium chloride ions to pass through those tiny little holes because they're just too small, but the water molecules can go back and forth. Got that scenario. OK.

Tracy: Ok.

John: So what's going to happen next? Understand that water will always go from where it's concentrated to where it's less concentrated. I'm not talking about the concentration of the salt. I'm talking about the concentration of the water. On the left side, you have pure water, on the right side you have saltwater. Where do you have more water for volume?

Tracy: On the left side

John: Yeah,

Tracy: And the

John: That's

Tracy: Side that has just

John: Just

Tracy: The pure

John: Pure

Tracy: Water.

John: Water. So what's going to happen is water is going to migrate from where it's pure into where it's not pure. Why? Because it's following a concentration gradient. It's going from where it's more concentrated to where it's less concentrated. Water is less concentrated in the salt solution. So what happens is the salts side begins to collect water molecules and

Tracy: You'll

John: You'll find

Tracy: Suck.

John: That the level of solution begins to rise.

Tracy: Mm hmm.

John: What's happening is water molecules are literally flowing from one side to the other because that partition. You'll see one side ends up being higher.

Tracy: Really?

John: You know, if you add more water to one side, it's going to get higher.

Tracy: All right.

John: Right. But you don't have to pour water in for that to happen. It's happening through those tiny little holes that plate a semi-permeable membrane permeable to water molecules, but it's not permeable to the solitude. In this case, the sodium chloride. This

Tracy: This

John: Whole

Tracy: Whole

John: Process

Tracy: Process.

John: We just described is called osmosis.

Tracy: Ok, so osmosis is when the water goes from high concentration to lower concentration

John: Yes.

Tracy: And it can pass through that plate, but it's not reversing because the.

John: That we we're just talking about osmosis here. Not

Tracy: Just

John: Reverse

Tracy: Osmosis.

John: Osmosis.

Tracy: I'm just saying that the salt isn't going from its side to the other side

John: Correct.

Tracy: Because it's

John: It's stuck.

Tracy: The

John: The Ion's.

Tracy: Ions are

John: Yeah.

Tracy: Too big to

John: He gets.

Tracy: Get through that semi-permeable membrane.

John: Correct.

Tracy: Ok.

John: Excellent. But of course, it would be rather difficult to create a semi-permeable membrane with them metal. So semi-permeable membranes are made with polymers. Nature is full of some permeable membranes. Take the skin of a cucumber. They take that cucumber and put it in a very, very, very salty solution in the concentration of water inside that cucumber will be greater than the concentration of water outside that cucumber. So water will travel down that concentration gradient from the inside of the cucumber to the outside of the cucumber. You are essentially dehydrating. That cucumber, which with the few spices turns into what we know to be

Tracy: Pickel.

John: A pickle. Pickles are made by the process of osmosis. The skin of a cucumber is a semi-permeable membrane. All right, back to our partition glass of water. Remember, water from the freshwater side is seeping into the salt water side. And as a consequence, the height of the liquid and the salt water side, it increases. So what if we did this, we pushed down on the surface of the saltwater solution really hard, we applied pressure

Tracy: Could

John: To

Tracy: You

John: Squeeze

Tracy: Squeeze the

John: The water.

Tracy: Water molecules

John: Yeah.

Tracy: Back to the other side?

John: To squeeze the water molecules back to the other side.

Tracy: You.

John: That's

Tracy: That's the

John: The opposite

Tracy: Opposite

John: Of

Tracy: Of osmosis.

John: Osmosis. And

Tracy: And so

John: So

Tracy: We

John: We

Tracy: Call

John: Call that

Tracy: That reverse

John: Reverse osmosis.

Tracy: Osmosis.

John: Notice

Tracy: Notice what

John: What

Tracy: You're

John: You're doing.

Tracy: Doing. You're

John: You're making

Tracy: Making

John: The

Tracy: The

John: Water

Tracy: Water

John: Go

Tracy: Go

John: To

Tracy: To

John: A

Tracy: A

John: Higher

Tracy: Higher concentration.

John: Concentration. You're

Tracy: You're

John: Making

Tracy: Making more

John: More fresh

Tracy: Fresh

John: Water.

Tracy: Water. Mm hmm.

John: Now,

Tracy: Now let's

John: Let's

Tracy: Just

John: Just consider.

Tracy: Consider keep.

John: Keep pushing. And you're going to have less and less water. On the one side. And you're going to have more freshwater on the other side. Why can't we just do this with ocean water

Tracy: It's like you're

John: Squeezing

Tracy: Squeezing

John: The

Tracy: The

John: Slaughterman?

Tracy: The water molecules out.

John: Yes.

Tracy: Yes, squeezable.

John: Squeezing water molecules through a semi-permeable membrane to make fresh water out of ocean water. And we do that on industrial scales even. It's called reverse osmosis. Now you can do it with saltwater, and that's actually rather difficult. You can do it with sort of saltwater or just maybe slightly impure water. It turns out the pressure you have to apply is not as great. It's one way industries will purify water rather than boiling and distilling it. They'll just pass it through these semi-permeable membranes through a process called reverse osmosis. That's it.

Tracy: Oh, where's that then?

John: We're

Tracy: Where

John: In

Tracy: In the world

John: Just

Tracy: Is that,

John: About

Tracy: Danu

John: Any water

Tracy: Water

John: Bottling

Tracy: Bottling?

John: System, actually. And you can get reverse osmosis devices I can put under your sink and do it right at home as well. You can be out in the ocean. You might have a reverse osmosis pump that if you need to survive out there in years, you're shipwrecked. You can transform the saltwater into freshwater.

Tracy: But

John: But why

Tracy: Why

John: Would

Tracy: Would

John: You?

Tracy: You have it under

John: Do you

Tracy: Your

John: Think

Tracy: Sink, is

John: That's

Tracy: That

John: A

Tracy: To

John: Cure?

Tracy: Purify the water?

John: Purify the

Tracy: The

John: Water.

Tracy: Water

John: You can use

Tracy: Is

John: A British

Tracy: Pretty

John: Filter

Tracy: Filtered.

John: Using charcoal to remove stuff from your water, or you can have the reverse osmosis device underneath that does pretty much the same thing. And get

Tracy: Get

John: This,

Tracy: This,

John: A

Tracy: A

John: Lot

Tracy: Lot

John: Of

Tracy: Of

John: Bottled

Tracy: Bottled

John: Water

Tracy: Water.

John: Is simply water from mountains that has been passed through reverse osmosis in marked up 3000 percent in price. Pretty

Tracy: Pretty

John: Silly

Tracy: Silly. And then driven

John: All around.

Tracy: All around.

John: Oh,

Tracy: Oh.

John: Moved from one part of the planet to the other.

Tracy: Other

John: Larry,

Tracy: In plastic

John: Carbon

Tracy: Bottles,

John: Dioxide and plastic

Tracy: Plastic

John: Bottles.

Tracy: Bottles,

John: Not

Tracy: No.

John: Good. Please, please consider getting yourself one of those reverse osmosis devices to put under your sink.

Tracy: You get

John: Your

Tracy: Your own bottled

John: Glass water

Tracy: Water

John: Bottle

Tracy: Bottle

John: That

Tracy: And

John: You carry

Tracy: Fill

John: Would

Tracy: It up

John: Carry with

Tracy: With.

John: You. Yeah. Fill it up with your Hiero water. Yes. So that that wraps it up for this chapter we covered first the dipole dipole ion dipole, dipole induced dipole induced dipole and this is dipole. Then we went over a bunch of terms that included solution, solubility, concentration. We learned about the mold, we learned about how solubility and temperature are related. And next time we're in this podcast series, we're going to be looking at water itself. Many of the remarkable properties of water.

Tracy: Wouldn't be here if we didn't have water.

John: Thank you so much for joining us here at the Big Picture podcast, too, next time. Good chemistry, good

Tracy: Good Chemistry

John: Good Chemistry

John: Theme Music by Zach Jefferey. Musical Flourishes by John Andrew from his green grass of home album. Production assistance from Greg Simmons and CPro music. As always shown notes are available at conceptual science dot com and that includes samples of student cartoon drawings of deoxygenated water. 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.