Lab 2A • 09/28/11

Our first experiment is going to be on one of the most common techniques that you're going to use in this class, which is extraction. Before we can get to extraction, though, we've got to build up to it a little bit. We're going to go back and talk about polarity, molecular polarity. From there, we'll connect that to solubility, because an extraction is a technique that takes advantage of solubility differences. You're not just doing a regular type of extraction, though; you're going to be doing an acid-base extraction. Then we'll get to the extraction.

To start off with, I've got two example molecules up here, one of which is a two-carbon compound that's called ethane. The -ane ending indicates that it is a compound that has just carbon-carbon single bonds, and the eth- part of it refers to a two-carbon compound. That is a compound that has a molar mass of about 30 grams per mole. Then, we have water, that has a molar mass of more like 18 grams per mole. Notice that the more massive molecule ethane exists as a gas at room temperature, but water, which is a less massive molecule, instead exists as a liquid at room temperature. Why? Why is it that the heavier one does stick together? It is because of intermolecular forces (IMF), which are attractive electrostatic interactions between molecules. Electrostatic means you have charges and it involves the attractions between those charges.

What causes a molecule to have intermolecular forces? You might guess polarity since that's our first topic. But what causes something to have polarity? Electronegativity, one of our periodic trends, one that you'll use all over the place. Electronegativity is the ability of an atom that's part of a bond to pull electrons in that bond towards itself. Electronegativity is the tendency for an atom to pull electrons towards itself when part of a bond. If I draw a block diagram {of the periodic table}, which directions along this diagram does electronegativity increase? Up and to the right. We ignore the noble gasses because they don't tend to bond. They're not terribly electronegative. Fluorine is therefore the more electronegative element. What rationalization can be used to explain why fluorine is the most electronegative element? It is related to octet behavior: the fact that fluorine is an octet if it has that one electron is part of the reason it wants to bring electrons to itself. The first energy level and second energy level are much closer to the nucleus so that positive charge has more of an effect, so yes, that positive charge is better able to pull electrons to itself. So a combination of its size and the fact that it's so close to being an octet, that's why fluorine is so electronegative.

We have this term polarity, and the term polar, but there is another term I'd like to define. What happens if you have two atoms that are connected by a bond and those two atoms have different electronegativities? What does that generate? What does that create? If you have oxygen and hydrogen, for example, those two atoms have different electronegativities. What kind of effect is that going to have on the bond? It's polar, but what other word can we use to describe this imbalance? Dipole.

What is a dipole? Having two different poles, like north and south if we're talking about a magnet or plus and minus if we're talking about charge. Since we're almost exclusively going to be talking about charge, I'll say that a dipole is a separation of charge in space. Bonds will have dipoles if the atoms in the bond have different electronegativities. Polar means, has a dipole.

There's a couple of different ways we can represent a dipole on paper. If I have water, for example – classic molecule with strong bond dipoles. One way to write the dipole is as an arrow, where opposite of the arrowhead you write a type of plus sign. The plus sign shows the atom that's less electronegative, so it's having charge taken away, that's why it's a plus; and then it points to where the electrons are going to. That does mean that a dipole is a vector quantity, meaning not only does it have magnitude, not only is there how much charge is separated, but which direction is it pointing. The other way to show dipoles is by the use of these little delta signs. Delta minus means something that's not a full negative charge, not a formal charge, but a little bit negative. Then delta plus means a little bit positive.

Having differences in electronegativity will cause a dipole in a bond. But, when is a molecule going to have a dipole? What causes a molecule to be polar? Electronegativity, yes, but what else? The structure. What specifically about the structure? Asymmetry. Imagine that you have two bonds in a linear molecule, and if those bonds are exactly identical with each other, then it's like you're having a tug of war, where one bond pulls the electrons one way, the other bond pulls it right back in the same place again, as if nothing had happened. That's what's going on a molecule like carbon tetrachloride.

{Explanation of dash-wedge, presented later}

This thicker line is the wedge, and that is the atom that is pointing out towards you. This dashed line represents an atom that pointed away from you. It's trying to give some small bit of dimensionality, to make it appear in 3D.

This molecule, carbon tetrachloride, what shape does it have? It's a tetrahedral shape. In fact, it's exactly a tetrahedron because all of the bonds in the molecule are identical. And that's what a tetrahedron is: a shape that has four sides where all vertices, edges, angles, everything else are identical. In this molecule, this is no net molecular dipole because all of the bond dipoles exactly cancel each other out.

Although the bonds in this molecule are polar, the molecule as a whole is non-polar because the dipoles all cancel each other. That's why I mentioned that a dipole is a vector quantity. It points a certain way. In this case, the four chlorines, the four dipoles, they point in a balanced way, so the molecule is non-polar. So in order for a molecule to be polar it must have asymmetry. Molecules will have dipoles if there is structural asymmetry. If we look back at ethane and water and draw the structure of ethane and water. Water, what kind of shape does it have? Bent. But bent is really a derivative shape of a tetrahedron. If we had the two hydrogen and we drew spaces representing where the two lone pairs are, we could connect those up as if it was a tetrahedron. But it's not a tetrahedron; it does not have four equal sides. It's got two bonds then two lone pairs, and the two bonds and lone pairs do not balance each other out. That's why water is, in fact, exceptionally polar, because it has really polar bonds and it's really asymmetric. If you look at ethane, you can image that you've got one tetrahedron here, well, almost a true tetrahedron. You have three of the same bond, but then you do have a carbon-carbon bond that's slightly different. But you have exactly the same pyramid right next door, so those two halves of the molecule exactly cancel each other out. So ethane is a very non-polar molecule.

That's part of the reason that water is a liquid at room temperature but ethane is a gas at room temperature. There's one other component to that, if we're talking about phase behavior, melting points, boiling points, and such. What's another way of explaining why water is a liquid at room temperature but ethane is a gas? It has to do with polarity, but what else is going on? There is this thing that's called a hydrogen bond, but that's a form of polarity, really. You could say that ethane is non-polar, but why does that mean it exists as a gas? It doesn't stick to itself, but what would be pulling it apart? What's causing the molecules to move away from each other? Not repulsion, per se. It's the fact that it has a temperature. What is temperature? Energy, kinetic energy. The fact that anything has a temperature is that molecules are constantly wiggling around. That's the missing component. At room temperature, there's a certain amount of latent kinetic energy that's inside these molecules. If you have something like ethane, that energy is able to cause the molecules to move apart from each other. But if you have something like water, that attraction between molecules is able to overcome the thermal energy and keep it together as a condensed phase. Water is a liquid at room temperature because its intermolecular forces are able to overcome thermal energy which is internal kinetic energy.

Solubility

Your starting materials for this lab are benzoic acid and naphthalene. Would you guess that naphthalene is polar or non-polar? Why non-polar? It's very, very symmetric. Mostly carbon-carbon bonds, and they're virtually identical. The carbon-hydrogen bonds are also very similar and they're symmetrically arranged. So yes, naphthalene is very non-polar. Would you guess that benzoic acid is polar or non-polar? I would call it only slightly polar, so mostly non-polar. If you look at the carboxylic acid group, that has carbon-oxygen bonds and an oxygen-hydrogen bond, which are rather polar bonds. But then we have this benzene unit, which again that benzene unit is very symmetric. And, if you ignore the carboxylic acid functional group, if you look at the whole rest of the molecule, how many atoms are there? An incautious answer might be six, but that's only counting the carbons. How many hydrogens are on that ring? 5, because each of these positions that does not have a substituent does have a hydrogen to bring carbon up to being tetravalent. Where the substituent is located there's already four bonds, so there's not a hydrogen there. Think of it this way, then: eleven atoms that are very symmetric, very non-polar, versus just these four atoms that are polar. So overall benzoic acid is non-polar because although the benzoic acid portion is polar, the larger very non-polar benzene outweighs it. Benzoic acid is non-polar because, although the carboxylic acid functional group is polar, the larger, very non-polar benzene ring outweighs the effect of the carboxylic acid.

Let's tackle some terminology

What is a solution? Can you give me a definition that doesn't use that "sol" prefix? A homogeneous mixture, which means if you zoom way down on the molecular level, you can't really tell one part of the mixture from another part of it; it's completely evenly dispersed throughout. What, then, is a solvent? I know you want to say thing that does the dissolving. It's the major component of a solution. The solute, therefore, would bethe minor component of a solution. What is the solvent and solute can flip-flop. You put a drop of water in ethanol, the water is the solute. You put a drop of ethanol in water, the water is the solvent. What does soluble mean? Able to form a solution with a particular solvent. So if I say sodium chloride, yes, that's soluble in water, but it's not soluble in benzene, for example. Miscible. Misc means mix. So miscable – mixable, you could say. Mixable in any proportion is what this term really means. So no matter how much or how little of the two solvents that you're putting together, they'll mix together. So miscible means two solvents that form a solution regardless of the proportions used. Immiscible means unable to mix regardless of the quantities used. It's this idea of having solvents that are immiscible that we take advantage of to do an extraction. The most common type of extraction is to take a water layer and some kind of organic solvent. Water and organics generally won't mix, they'll form two separate layers. Why would we even do an extraction? Because in a chemical reaction, we might have multiple products. If we're creative in the way we do an extraction, we're able to target product and get it into one of the layers, either the organic or the water layer, while the other product stays in the opposite layer.

Why would something like benzoic acid, that's not polar, fail to dissolve in water? Why is it that oil and water don't mix? There is this common phrase that's used: like dissolves like. Polar dissolves polar. Non-polar dissolves non-polar. But, why? Since water is polar and has these little grips on the molecule, one water is attracted to another and, you could say, pushes the non-polar molecule out. But that's not quite the real reason. It has to do something with the special properties of water, which is the fact that when you freeze water, what happens? It expands. Water is a very unusual substance. Almost all of the substances in the universe contract when you cool them off, which means the molecules are moving closer and closer together. But if you have frozen water, you really have something like this. Since water is so incredibly polar, and yes, it has these things called hydrogen bonds, but I don't like that term because it's not a bond, it's just an extraordinarily strong intermolecular force. But ok, let's use that term. It's got these hydrogen bonds that, when water cools down, those bonds pull the water apart, it makes that space, that's why water's less dense, that's why water expands, that's why you don't put glass bottles in the freezer. In this kind of situation, forming this hexagonal pattern, is that a favorable or unfavorable process from the perspective of entropy? Is it a positive or negative entropy change? What is entropy? It's disorder, but a more elegant way of saying that is that it's the tendency for matter and energy to become homogenized, to spread out. You clap two chalk erasers together, the chalk doesn't come together in a nice little pile, it spread every which way, it spreads out as much as possible. That's entropy. In this case, if you're making this hexagon, you're ordering the system, you're removing entropy. Indirectly, there's an energy cost to doing that. So, in fact, for all substances, when you go from liquid to solid, you're reducing entropy. Now imagine this: you've got liquid water. Liquid water is a totally random arrangement of molecules, more entropy. Let's say you try to stuff a non-polar molecule into water. What ends up happening is that non-polar molecule would end up being the same type of thing as the space that's generated when water freezes. It would push water into being more ordered. So the act of taking a non-polar solvent and mixing it with water causes a negative entropy change. Negative entropy means positive free energy which doesn't want to happen. When someone asks, instead of saying something about polarity or intermolecular forces, you could give a one-word answer: entropy. Entropy is the reason.

Let me give you some common organic solvents.

One extremely common one is hexane, or even more common is something called hexanes, with an "s". Hexanes is a mixture of isomers, which are molecules with the same molecular formula but different structure. Acetone. Dissolves all kind of organic molecules. Happens to be water-soluble too, though. That's because it's very polar. It's got a carbon-oxygen bond that's right in the middle and the carbon groups on either side are not big enough to outweigh the polar bond. This molecule, what I've written so far looks like acetate, which is related to acetic aid. If I replace the hydrogen that would be on acetic acid with a carbon group, I form a functional group called an ester. This is called ethyl acetate. The two-carbon group .... You saw the name earlier, ethane; that's when you're talking about a distinct compound. But when that ethane is substituted on something, becomes a substituent, we use this -yl ending to show it's a substitute. So ethyl acetate means put an ethyl on acetate. CHCl3, chloroform. CH2Cl2, dichloromethane, also called methylene chloride. The first one, dichloromethane, is the IUPAC name, the systematic name, the second one, its common name. Diethyl ether, which because it is so common, it is just called ether. Ether is technically a functional group, but if you just call something ether, it 99% of the time refers to diethyl ether.

Acid-base neutralizations

This is not a normal extraction that you're doing today; this is an acid-base extraction. You're going to be starting with benzoic acid and what base? Sodium hydroxide. Benzoic acid has a pKa of 4.2. Then we have sodium hydroxide that, when it reacts with it, form sodium benzoate. Just like acetic goes to acetate, benzoic goes to benzoate. Of course, we'll have water left over as a by-product. Water as a pKa of 15.7. Based on these pKa values, would you say this neutralization really does occur?

{need to know pKa after o-chem for biochem}

If you're dealing with amino acids that have two or more pKa values to them, which you can determine by using the half-equivalence point during a titration, which you can also describe using the Henderson-Hasslebach equation.

pKa is the – log of a Ka value, which Ka in turn is the acid dissociation constant, which we we write as H+ and A– multiplied together over HA. To put that in looser terms, it's how much of an acid likes to automatically dissociate when you throw it into solution, versus how much of that acid stays together. It's really indicating how much dissociation. So you can have some acids that have very large Ka values, Ka must greater than one; that means you're going to have a pKa less than zero once you take that negative log. It means extensive dissociation. When you have an acid like this that has large Ka, small pKa, dissociates a lot, what do we call that? A strong acid. Strong doesn't mean hazardous, it means tends to dissociate. Then if you have a Ka much less than one, which if you look at the expression for Ka means the denominator is big, which means most of it does not dissociate. Negative log of a small number is going to be a positive number, so pKa greater than zerp, which means we have minimal dissociation. What do we call that? A weak acid.

The stronger an acid is, the weaker its conjugate base is. If you think of it this way: if you have an acid that's strong, that likes to dissociate, it likes to get rid of its H+, which means whatever's left over afterwards does not want to take that H+ back. Similarly, if you have a weak acid, it does not want to let go of that proton, and so if it gets ripped off, it wants it back. So the conjugate is basic.

Let's rewrite this topic equation without the mechanism, just stoichiometrically. Which one of those two, benzoic acid or water, is the stronger acid? Benzoic acid, because it's got the lower pKa, so it's got the higher Ka. So benzoate is the weak base, and hydroxide, being the conjugate of water, is the stronger base. I use the terms stronger and weaker because benzoic acid is not a strong acid, but it's stronger than water. Because we have the stronger acid and the stronger base reacting, because we have a molecule that wants, in comparison, to let go of its proton, and then one that wants to bring one back, yes, this reaction's going to go forward.

{discussion of lab procedure}
{specification of reduced quantities}

Let me show you a separatory funnel. The separatory funnel has got a large chamber for doing the mixing; it has a value at the bottom of it, and at the top, it has a stopper. Notice that this came with a piece of [paper] in it, and that's because when one piece of groung glass contacts another for an extended period of time, it's possible those will get or frozen. If they are going to be stored unused for a while, make sure that you do so with the piece of paper in there. The stockroom will test the funnels and send you back to clean the if they are found to be over acidic or basic.

If you're going to store something using a glass stopped, we do have grease. If you use the grease, you only need the tiniest little dab of it, just a small smidgen. If you take it and turn the stopper with the grease on it, it'll spread the grease out, it will make a seal, but you'll be able to get it back open. That's why some of you in your glass kits you've got brown all the way around the openings of a lot of the pieces of equipment – that's grease from previous quarters. Don't use the grease for separator funnels, though, since you're not going to be using them long enough for that freezing behavior to happen. Before you put any liquid in the funnel, make sure the valve is perpendicular to the flow of the liquid. So this crosses where the liquid is flowing, so it's closed; when you turn it so it's parallel, then it's open. When you go to mix, don't just put this stopper on here and just start shaking it around, as I did when I was an undergrad student and then managed, in front of the instructor, to cause the cork to pop off and fly across the room. I learned by my mistake. The way that you really should do it is hold the entire separatory in such a way that you cover the stopper. Make sure you've got a fairly good grip. You want to avoid this thing freezing, but if you don't hold it at all, then gravity's going to pull it out and you're going to get your solution all over yourself. Turn the whole thing upside down, point it away from yourself or anybody else. It happens so commonly that people are doing reactions and they've got boiling beakers of something that bring right up to me and say, "Here! What does this look like?" Just think a little bit when you start pointing glassware around.

You're going to have it held like this. Shake it, but particularly since you're using ether, ether evaporates very easily, you're going to build pressure up. So don't shake it too hard or too long before you open it and vent. Make sure that it is upside-down so the liquid drains, when you vent it you're not spurting anything out. Close it up again, shake again, open it, close it, shake it a little more vigorously because you've vented some of that pressure, vent it one last time, close it one last time, turn it rightside-up again and let the layers separate.

There are not enough of these for you to keep them in your lab lockers so you must turn them back in at the end of the day.

You have the benzoic acid and naphthalene that you're going to dissolve in ether and then put in the separatory funnel. You then add the sodium hydroxide, which is going to cause two layers to form. Ether versus sodium hydroxide, which means water: which one is on top? Sodium hydroxide will be on the bottom, which means ether will be on the top. Why? Density, ether is less dense. Once you've added the sodium hydroxide, it will have already reacted with the benzoic acid that's in there, or if it hasn't yet by the time that you shake it, it will have reacted. So once the layers separate, you're going to have water plus the sodium benzoate in your lower layer (hydroxide extract). Then the top layer will be ether plus naphthalene.

You're going to separate these layers. The first layer that you drain is going to be the aqueous layer because it's the lower one. You've got to just try to be careful and stop that valve right at the point where you can see that the layer has drained out. If a little bitty bit of the organic drains in with the aqueous layer, know for next time you need to be more careful, or, if you see a substantial aqueous layer left, you're going to have to open that up and drain some of it out. If you careful open and close that valve, then, you should be able to get a gentle flow of solution coming out. Don't just twist it; you have some ability to control it. You're going to drain the aqueous layer. What eventually are you going to be doing with that solution? Reacidify. The whole trick that is being pulled here is what?

Benzoic acid is mostly non-polar because the benzene portion of the molecule outweighs the polar acid group. But one you take that hydrogen off, it's not polar any more, it's charged, and charge is the strongest form of intermolecular force, over permanent dipoles, over temporary dipoles. So now, because this is charged, it outweighs the benzene portion of the molecule.

Because it's now polar, that's why it goes into the aqueous layer. That's how we're able to do the extraction because we've changed the polarity of the molecule. By neutralizing benzoic acid and forming an ion, the molecule becomes polar because the ionic portion outweighs the non-polar benzene. And now, since it's polar, it dissolves in the aqueous layer

Hydrophobic and hydrophilic

Hydrophobic literally means water-fearing. So if it's hydrophobic, it's not going to be soluble in water. Hydrophilic means loves water, which means it's water-soluble. This same thing that we're doing with benzoic acid, where we neutralize it, make an ionic compound out of it, that's what we do to make soaps. Soaps are really long molecules, most of which are non-polar except for one little group at the end that is polar. When you throw soap into water, the polar portions congregate as a sphere, what is known as a micelle, inside of which you've got all of the oily bits that are congregating together cause they don't like the water. You throw soap into a sink; the grease and whatever else dissolves in that hydrophobic portion, or sometimes we use the term lipophilic, something that likes fats. That all stays on the inside. Then that whole ball of grease literally has a polar surface that that whole thing can dissolve in water.

We're going to have the aqueous layer, to which we will add hydrochloric acid, which means you would have sodium benzoate react with HCl to reform benzoic acid, plus you'll have salt, sodium chloride, left over as a byproduct. Because you've reformed benzoic acid you've made it non-polar again. Because it was in water already and now became non-polar, it's going to precipitate out. That's why you're going to end up doing filtration.

What about the other layer? You're going to end up evaporating off that ether.

Part of what you're going to learn how incredibly long it takes to get the heck out of here.

Labeling chemicals

All things that you store – which you can store things in your lab locker – must be labeled. That's so if there's an emergency – particularly a fire – that if the fire crew comes in here and tries to identify the source of the fire or identify the hazards in this room .... Imagine a fire in a chemical storage facility, not a fun thing. They want to be able to rapidly identify the hazards. Here's the information you must have on your beakers. You need your name, the chemical names – not structures, not pictures, the actual chemical names – of the stuff that's in the beaker, and then the date. For liquids, they have to be sealed up, they have to be stoppered. For solids that are non-volatile – because you can have solids that have a vapor pressure because you can have solids that sublimate – those can be kept open, so if you have something you want to dry on a watch glass, for example. But you need to label your samples.

Storing chemicals

You have a mixture of ground-glass and non-ground-glass glassware. Your beakers and Erlenmeyers, for example, they may come to a narrow top like this, but they're not ground glass. You cannot use your ground-glass stopper to stopper an Erlenmeyer. You just won't get a good enough seal. Parafilm is totally inadequate as a seal. You cannot use Parafilm in the place of a stopper. It's supposed to be just a back-up, a sort of assistant, for the stopper. To use Parafilm, get your appropriate stopper first. For some sizes of glassware in your kit you might be able to use your blue rubber stoppers. If those don't fit very well, the stockroom checks out all different sizes of stoppers, so you can keep things sealed up. Once you have your stopper to put Parafilm on, hold it with one thumb or finger, gently stretch it, because the more that you stretch without breaking it, the stickier it gets. As you've got it stretched, wrap it around your stopper. Squish it together. That makes a back-up seal. But, ether eats through this stuff like water eats through salt, so that's why you can't use Parafilm as the only way to seal off these containers.

You need to stopper both of your liquids. I'm recommending that you Parafilm it after that, and remember that you need to label it before you leave.

Chemical pet peeves

You are not kids. You are second-year college students. If you want to be treated like college students, you need to act like the adults that you are, and if you want me to treat you like little kids, then act like little kids in lab. What do I mean by that? This is not your lab, this is ours. You're using this space .... In fact, this is not even mine; I'll be gone one of these days too; it's the institution's. When we come here, we've got to leave here and leave this space the way that we found it. As soon as these labs start to meet here, within the first week, I bet I can go around, and like .... These pieces of Parafilm. I wouldn't be surprised if I found, like I did this morning from a previous quarter, these little pieces of paper just sitting around because someone couldn't walk the three steps it takes to get it into the trash can. The balance area over here. The first chemical that gets opened up, I know it's going to get spilled around the balance. And so what often happens is that the balance is just a giant mess. Sometimes people try to clean it up before the end, and sometimes [they] don't; it just gets left a mess.

You are college students, so I don't understand what is so difficult to understand about this: that if you have a bottle of chemicals that you've opened, does any stretch of the imagination let you think that just putting the cap on here means this is closed? This is concentrated sulfuric acid, With the cap not properly put back on like this, if I waved some pH paper here, it's going to turn red, because of the fumes coming off of this. Even if it's not a liquid, even if you're just using the balances, you're going to use in the future a compound called aluminum trichloride, which decomposes into hydrochloric acid upon contact with air. Think about that: decomposes into hydrochloric acid, which we know how hazardous hydrochloric acid is, right? I bet you that, during that lab, if I didn't yell at you, that there would be yellow powder sitting all over this thing. Which means anybody walking in this area would be just breathing in the hydrochloric acid that's coming off of it. It is a safety hazard, it's just completely unprofessional for the messes to be made that past quarters have always made.

And so, here's my solution to it. If during the lab – not just at the end when you all are in a rush to make me happy – no, you've gotta make me happy the whole day long. If I see a mess around the balance area, this entire lab gets zero on the experiment. That sounds harsh, but realize I can't fire you, and I certainly can't come up and smack you all around. But if you were working in a real science lab and you make the type of messes that you all make here you would be gone, because it is a safety hazard. You just can't do it. And I mean the first time a see a mess. If I come over here and no one's here .... Another thing that happens: people walk off and leave chemical bottles open, so they're sitting decomposing, contaminating us, the chemicals are getting ruined. We have to spend more money for the chemicals which is why we can't open more sections of classes. So, the first time I see this place a mess, you will all get zeros on your lab reports. Why am I targeting everybody? Because I can't figure out who did it, but you are all equally responsible. I'm not going to ask anyone to police each other, but if you see someone that's consistently making a mess, tell me. You don't have yell at them; I'll get on their case. Same thing happens with pH paper. The first time we use pH paper in the lab, there are these little pieces of paper everywhere, especially in these drains, which when, not if, the inspectors come to look at this place, when they see something like that, then they're going to say, "Wait, what have you been dumping own that drain?" And then a whole mess of trouble begins. The chemical bottles, if you don't put the caps back on them, again, a huge problem. Secondary containment – if you can't be bothered to figure out if you're putting the bottle down in the right place, you don't need to be in this lab. If you keep this place clean and act like adults, I'll treat you like adults, respectfully. if you can't be bothered to clean up, I'll give you a zero for the lab.

It's really easy to avoid that: don't be irresponsible. When spills happen, that's not a big deal; what you do about it is a big deal. There are brushes over here so you can brush the stuff up and put it into a waste bottle. That's all you gotta do to make me happy. When you use the Parafilm, throw the back part of it away. When you use the pH paper, go throw it in the waste. That's all you gotta do to make me happy.

{plea for being on time}

If I'm even five minutes late leaving this lab, I still have to go back to the office, grab my microphones, deal with the three of four people who attack me as I'm walking around: they see me: "oh, I've got this question! I've got this question!" Shake them off. Get to the lecture in time, get everything set up and actually have the mental frame of mind to lecture the way I do, I can't be late at all.

Every minute that you're late getting out of lab, you individually, not the whole class, lose a point off your lab report. In past years where I didn't have that policy, it'd be 5 more mintes, 10 more minutes, 15, 20. Oh just one more thing. Oh I just gotta clean that up. 30 minutes of cleaning glassware later I'm still waiting around to go home. We have students that work in the stockroom. If you all turn your equipment in late, he's glaring at you because he knows he's going to be late for lab lecture, and he's in this class. Every minute past the end of lab is a point off your lab report. What many people don't realize is 10 minutes is not enough time to clean up. I will start yelling at the 20-minute mark to say you need to start cleaning up. If you're an organized person, if you're a fast person, you may know: ok, I've got 10 more minutes, now I really need to get on it. But the end of the first day of class, you wouldn't believe the panic I saw, all the people rushing around; "crap, he's gonna take points off!" Today's the day you learn how long it takes to put things away.

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polarity
solubility
acid-base neutralization
extraction
chemical pet peeves

H3C – CH3 (ethane); MM = 30 g/mol; gas @ RT
H2O; MM = 18 g/mol; liquid @ RT
why??
IMF – intermolecular forces – attractive electrostatic interactions between molecules
electronegativity – the tendency for an atom to pull electrons towards itself when part of a bond.
dipole – a separation of charge in space
Bonds will have dipoles if the atoms in the bond have different electronegativities.

polar – has a dipole

Although the bonds in this molecule are polar, the molecule as a whole is non-polar because the dipoles all cancel each other. Molecules will have dipoles if there is structural asymmetry.

Water is a liquid at room temperature because its IMF are able to overcome thermal energy (internal kinetic energy)

Solubility

Benzoic acid is non-polar because, although the carboxylic acid functional group is polar, the larger, very non-polar benzene ring outweighs the effect of the carboxylic acid.

solution – a homogenous mixture
solvent – the major component of a solution
solute – the minor component of solution
soluble – able to form a solution with a particular solvent
miscible – two solvents that form a solution regardless of the proportions used
immiscible – unable to mix regardless of the quantities used

hexanes (with an "s") – a mixture of isomers (molecules with the same formula but different structure)

The stronger an acid is, the weaker its conjugate base is.

By neutralizing benzoic acid and forming an ion, the molecule becomes polar because the ionic portion outweighs the non-polar benzene.

hydrophobic – "fears water" – not soluble in water
hydrophilic – "loves water" – water-soluble

Structures

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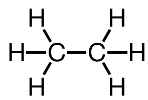
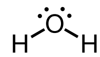


molar mass ≈ 30 g/mol
gas at room temperature



molar mass ≈ 16 g/mol
liquid at room temperature

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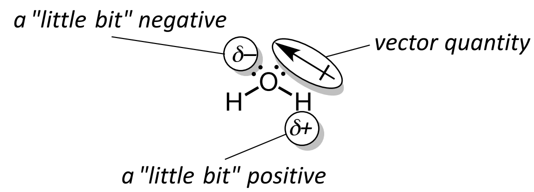

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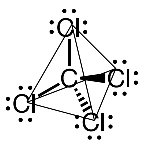

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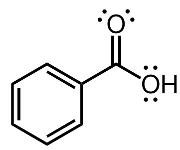
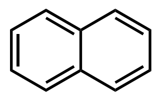


benzoic acid
non-polar
(very slightly polar)



naphthalene
non-polar

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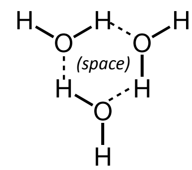

ice

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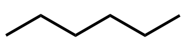
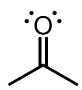
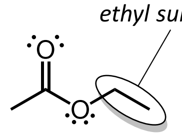


hexane



acetone



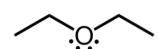
ethyl acetate

$CHCl_3$

chloroform

CH_2Cl_3

dichloromethane
(methylene chloride)



diethyl ether
(ether)

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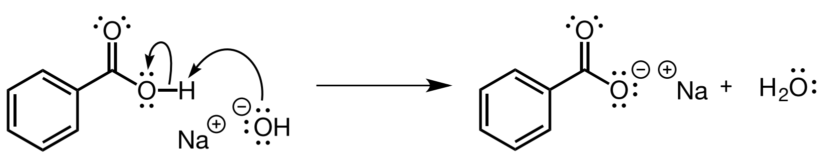

pK_a = 4.2 | sodium benzoate | *pK_a = 15.7*

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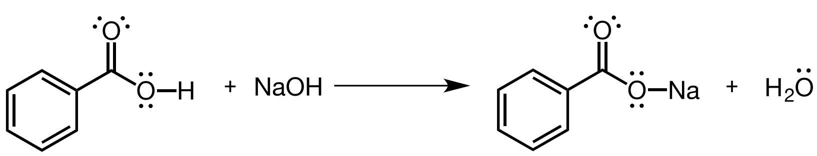

stronger acid
pK_a = 4.2

stronger
conjugate base

weaker
conjugate base

weaker acid
pK_a = 15.7

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