Chemistry in the Library:

What you can't see… - Water Chemistry

Website: http://mdchem.org/citl/citl_main.html
e-mail us at: **chemists4fun@yahoo.com**

- What do you think of when someone says 'water'?

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- Why is water important?

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Water is of major importance to all living things; in some organisms, up to 90 percent of their body weight comes from water!! Up to 60 percent of the human body is water, the brain is composed of 70 percent water, blood is 82 percent water, and the lungs are nearly 90 percent water.

Let's challenge your knowledge about water with the following True/False quiz:

(borrowed from the US Geological Survey site: http://ga.water.usgs.gov/edu/mwater.html)

1. Water contracts (gets smaller) when it freezes.
2. Water has a high surface tension.
3. Condensation is water coming out of the air.
4. More things can be dissolved in sulfuric acid than in water.
5. Rainwater is the purest form of water.
6. Sea water is slightly more basic (the pH value is higher) than most natural fresh water.
7. Raindrops are tear-shaped.
8. Water boils quicker at Denver, Co. than at the beach.

<u>Answers:</u>

1. **False:** Actually, water expands (gets less dense) when it freezes, which is unusual for liquids. Think of ice -- it is one of the few items that float as a solid. If it didn't, then lakes would freeze from the bottom up (that would mean we'd have to wear wet suits when ice skating!), and some lakes way up north would be permanent blocks of ice.
2. **True:** Water has the highest surface tension among common liquids (mercury is higher). Surface tension is the ability of a substance to stick to itself (cohere). That is why water forms drops, and also why when you look at a glass of water, the water "rises" where it touches the glass (the "meniscus"). Plants are happy that water has a high surface tension because they use capillary action to draw water from the ground up through their roots and stems.
3. This is actually **true** -- water that forms on the outside of a cold glass or on the inside of a window in winter is liquid water condensing from water vapor in the air. Air contains water vapor (humidity). In cold air, water vapor condenses faster than it evaporates. So, when the warm air touches the outside of your cold glass, the air next to the glass gets chilled, and some of the water in that air turns from water vapor to tiny liquid water droplets. Clouds in the sky and the "cloud" you see when you exhale on a cold day are condensed water-vapor particles. (It is a myth that clouds form because cold air cannot hold as much water vapor as warm air!)
4. **False**. Sulfuric acid might be able to dissolve a car, but water isn't known as the "Universal Solvent" for nothing! It can dissolve more substances than any other liquid. This is lucky for us... what if all the sugar in your soft drink ended up as a pile at the bottom of the glass? The water you see in rivers, lakes, and the ocean may look clear, but it actually contains many dissolved elements and minerals, and because these elements are dissolved, they can easily move with water over the surface of the earth.
5. **False.** Distilled water is "purer." Rainwater contains small amounts of dissolved minerals that have been blown into the air by winds. Rainwater contains tiny particles of dust and dissolved gasses, such as carbon dioxide and sulfur dioxide (yep, acid rain). That doesn't mean rainwater isn't very clean -- normally only about 1/100,000th of the weight of rain comes from these substances.
   In a way, the distillation process is responsible for rainwater. Distilled water comes from water vapor condensing in a closed container (such as a glass jar). Rain is produced by water vapor evaporating from the earth and condensing in the sky. Both the closed jar and the earth (via its atmosphere) are "closed systems," where water is neither added nor lost.
6. **False.** First, water at boiling temperature (212° F at sea level) is not really the same as boiling water. When water first reaches boiling it has not begun to turn to steam yet. More energy is needed to begin turning the boiling liquid water into gaseous water vapor. The bonds holding water molecules as a liquid are not easily broken. If I remember correctly, it takes about seven times as much energy to turn boiling water into steam as it does to heat water at room temperature to the boiling point.
7. **True.** They don't call it the Great SALT Lake for nothing. Water in the Great Salt Lake varies in salinity both by location and in time. In this example, we are assuming about a 20-percent salt concentration. In other words, about one-fifth of the weight of the water comes from salt. And how much saltier is Great Salt Lake water than seawater? Quite a bit. Seawater has a salt concentration of about $3\frac{1}{2}$ percent.
8. **True.** Neutral water (such as distilled water) has a pH of 7, which is in the middle of being acidic and alkaline. Seawater happens to be slightly alkaline (basic), with a pH of about 8. Most natural water has a pH of between 6-8, although acid rain can have a pH as low as 4.
9. **False.** When you think of a drop of falling water you probably think it looks like . When a drop of water comes out of a faucet, yes, it does have a tear shape. That is because the back end of the water drop sticks to the water still in the faucet until it can't hold on any more. But, using high-speed cameras, scientists have found that falling raindrops look more like a small hamburger bun! Gravity and surface tension come into play here. As rain falls, the air below the drop pushes up from the bottom, causing the drop to flatten out somewhat. The strong surface tension of water holds the drop together, resulting in a bun shape (minus the sesame seeds).
10. **True.** The boiling point of water gets lower as you go up in altitude. At beach level, water boils at 212° Fahrenheit. But at 5,000 feet, about where Denver is located, water boils at 202.9° F, and up at 10,000 feet it boils at 193.7° F. This is because as the altitude gets higher, the air pressure (the weight of all that air above you) becomes less. Since there is less pressure pushing on a pot of water at a higher altitude, it is easier for the water molecules to break their bonds and attraction to each other and, thus, it boils more easily.

Safety Rules

- **Wear safety goggles.** This means from when you're told to put them on until you're told they can come off.
- **Detect odors safely.** Use you hand to wave fumes to your nose. Never stick your nose directly into anything.
- **Wash spills immediately.**
- **No running, pushing, or shoving.**
- **Clean up your mess!**
- **Get help.** If you have any questions, please ask before proceeding.
- **No eating or drinking.**
- **No unauthorized experiments.** Only do the things the leader tells you to.

Remember, the most important thing a scientist does is make observations! The understanding comes later sometimes!

Experiment #1: Is my Water really clean?

Materials

3 jars each with a different type of water	3 types of water: tap water, water that has dirt, leaves, stuff in it, soapy water	
Disposable pipets	Microscope slides	microscope

In front of you are 3 jars – one has water from the sink (tap water), one has water that is growing stuff in it, and one has soapy water in it.

- Using **Jar #1** (tap water): Take your disposable pipet and place 1 drop of water on a microscope slide from jar #1
- Put the slide under the microscope
- Make observations:
    1. Can you see anything in the water?

    2. What does the drop look like under the microscope?

- Using **Jar #2** ('growing' water): Take your disposable pipet and place 1 drop of water on a microscope slide from jar #1
- Put the slide under the microscope
- Make observations:
    1. Can you see anything in the water?

2. What does the drop look like under the microscope?

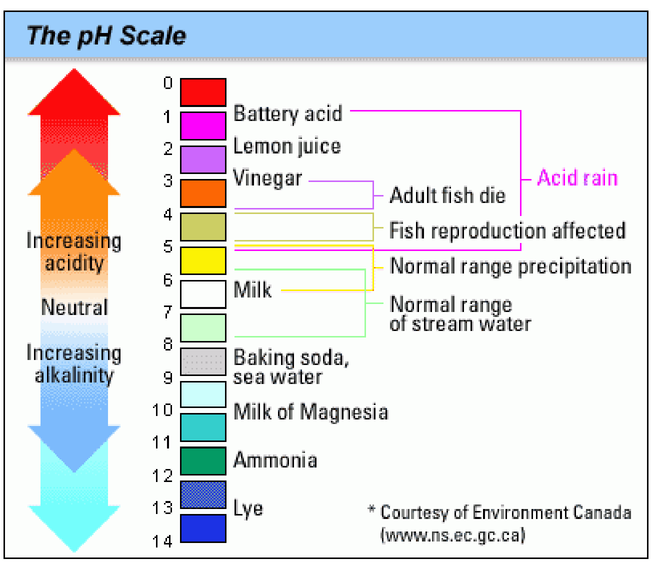
- Using **Jar #3** (soapy water): Take your disposable pipet and place 1 drop of water on a microscope slide from jar #1
- Put the slide under the microscope
- Make observations:
  1. Can you see anything in the water?

  2. What does the drop look like under the microscope?

Experiment #2: The pH of Water

Materials:

7 small vials	Samples: water from the sink, soapy water (from bath or hand washing), soapy water (from dish soap), orange juice, vinegar, baking soda solution, ammonia – or substitute any one of these with another liquid or solution
pH paper	



As this diagram shows, pH ranges from 0 to 14, with 7 being neutral. pHs less than 7 are acidic while pHs greater than 7 are alkaline (basic). You can see that acid rain can be very acidic, and it can affect the environment in a negative way. Not only does the pH of a stream affect organisms living in the water, a changing pH in a stream can be an indicator of increasing pollution or some other environmental factor.

Take a look at the sample vials with the different solutions in them. What are the similarities? What are the differences?

See the table below – you will be measuring the pH of water samples and liquid samples that are mostly water.

Sample	pH
Water from the sink	
Water with soap in it (i.e. bath water)	
Water with dish soap in it (i.e. dish water)	
Orange Juice	
Vinegar	
Baking Soda Solution	
Ammonia	

How do the pH's of the different liquids compare to each other?

Which liquid has a pH most like pure water?

Experiment #3: Separation of Kool Aid from Water

This experiment was compliments of the ACS Earth Day packets donated to the ACS by Waters Corporation for use in the Chemists Celebrate Earth Day activities.

Materials:

1 envelope Kool-Aid brand unsweetened soft drink mix	5 vials	4 small Petri dishes
25-mL or 50-mL plastic syringes (must show gradations)	2 Sep-Pak Classic C_{18} separation cartridges (Water part #WAT051910)	5 solutions: kool-aid grape drink, 9% isopropanol (isopropanol = rubbing alcohol), 35% isopropanol, 70% isopropanol, water

This experiment introduces the principles of liquid chromatography (a method for separating liquids) and solid-phase extraction. You can use reverse-phase liquid chromatography to separate the ingredients in the Kool-Aid Drink mix.

Kool-Aid Drink mix contains:

Chemical	Fraction	Polarity
Citric Acid	1	Polar
Calcium phosphate	1	Polar
Ascorbic Acid	1	Polar
Red Dye #40	2	Less Polar
Blue Dye #1	3	Still Less Polar
Artificial flavor	4	Nonpolar

Each ingredient (component) in the Kool-Aid Drink mix has a certain polarity. When the polarity of the ingredient is closer to that of the sorbent (the stuff packed in the separation cartridge) than that of the eluent (the liquid, water), the ingredient stays adsorbed to the sorbent. When the polarity of the ingredient is closer to that of the eluent, it remains with the eluent and is eluted from the cartridge. You use water (which is very polar) to elute polar compounds like acids, and use less polar solutions (like isopropanol) to elute less polar compounds like flavoring oils.

Prepare Solutions (adult can do this ahead of time):

Solution A: the Kool-Aid Drink mix. Dissolve 1 envelope Kool-Aid Drink mix in 2 litres of water. Do not add sugar.

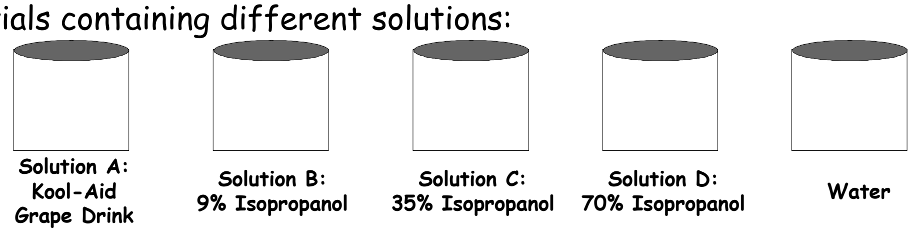
Solution B: 9% isopropanol. Prepare by combining 20-mL of water and 2-mL of 70% isopropanol.

Solution C: 35% isopropanol. Prepare by combining 20-mL of water and 20-mL of 70% isopropanol.

Solution D: 70% isopropanol, straight out of the bottle.

Filtered Water: should have about 40-50mL available

Now, you have 5 vials containing different solutions:



Experiment:

1. First, 'condition' the dry cartridge:
    a. Draw 10 mL of Solution D into the syringe. Expel air from the syringe.
    b. Fit the syringe tip to the Sep-Pak cartridge and push the syringe plunger, forcing the isopropanol through the cartridge and into a collection beaker.
    c. Repeat steps 1 & 2 with 10 mL of pure water

2. Now load a sample into the cartridge:
    a. Draw 3mL of Solution A into the syringe. Expel any air from the syringe.
    b. Fit the syringe tip to the Sep-Pak cartridge and push the syringe plunger, forcing the Kool-Aid into the cartridge. Watch a dark purple band form at the top of the cartridge as the water passes through the cartridge, leaving the flavoring and coloring agents behind.
3. To separate and 'elute' the components of the Kool-Aid mixture, wash them out with solutions of like polarity. Solution A is your sample. Solutions B, C, and D are your eluents, in order of decreasing polarity.
    a. Use 10 mL of water to elute the polar citric and ascorbic acids and the calcium phosphate into a petri dish – **this is Fraction #1**
    b. Use 10 mL of Solution B to elute the less polar red food coloring into another test tube. Observe the band of red food coloring as it passes down the Sep-Pak cartridge and into the petri dish - **this is Fraction #2.** The blue food coloring remains on the cartridge because it did not dissolve in Solution B.
    c. Elute the blue food coloring with 10 mL Solution C into a third test tube. Observe the band of blue food coloring as it passes down the Sep-Pak cartridge and into the petri dish - **this is Fraction #3.**
    d. Elute the artificial flavor with 10 mL Solution D into the fourth petri dish - **this is Fraction #4**. Can you smell anything in this fraction?

Make some general observations about the fractions. What do they look like, what do they smell like.

Now, measure the pH of the different fractions. What, if anything, is the difference?

Fraction:	**Observations:**	**pH:**
Fraction #1: polar citric and ascorbic acids and the calcium phosphate		
Fraction #2: red food coloring		
Fraction #3: blue food coloring		
Fraction #4: artificial flavor		

Experiments To Do at Home with a friend and/or a parent:

- When working at Home: ALWAYS remember the safety rules!!
- When working at Home: ALWAYS ask a parent before you start any experiment!!
- When working at Home: ALWAYS remember to work on a surface that is easily cleaned – never work directly on a table. Working on a wax paper or plastic surface will minimize any problems with cleaning up afterwards!

Experiment (To Do at Home!): Surface Tension

The cohesive forces between liquid molecules are responsible for the phenomenon known as **surface tension**. The molecules at the surface do not have other like molecules on all sides of them and consequently they cohere more strongly to those directly associated with them on the surface. This forms a surface "film" which makes it more difficult to move an object through the surface than to move it when it is completely submersed.

Experiment with surface tension:

1. Take a shallow dish and put water in it
2. Now, try to 'float' things on the surface of the water:
    a. A needle (otherwise known as a compass)
    b. A button
    c. A drop of liquid soap – watch carefully what happens
    d. A piece of candle wax

Experiment (To Do at Home!): Water, Water, Everywhere, Nor Any Drop to Drink

Check out the activity on-line at:
http://www.nytimes.com/learning/teachers/lessons/19981208tuesday.html?searchpv=learning_lessons