

YOUR NAME

# WATER PACK

## THE BASICS + NOTES COMBINED

"THE GREAT WAVE OFF KANAGAWA" BY HOKUSAI (1760-1849)



# Water Basics

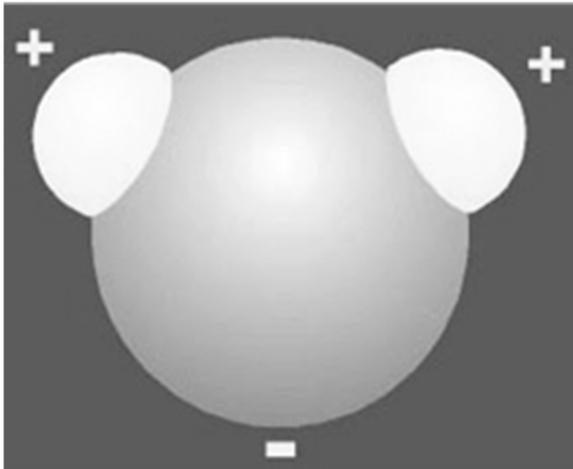
One of the most important molecules in chemistry class is dihydrogen monoxide. You drink it, swim in it a lot, splashing it, cooking food in it, spraying it on the grass, do dishes in it, wash your clothes in it, bath in it, skate on it, and throw it at friends on cold days. You have molded it into somewhat rounded but human like forms and used a carrot for a nose, shovel it, celebrate when it falls too quickly to allow safe passage to school, cool your sodas with it, and on and on.

Water is pretty cool stuff, even when hot.

It makes nice pictures, it has physical properties we can measure, and all of its properties come about directly or indirectly by the hydrogen bonding between the water molecules.



Water is a very polar molecule. It does not have RADIAL SYMMETRY, which would allow its very polar bonds to “offset” each other. The water molecule does have bilateral symmetry, the same as humans, but that doesn't matter in chemistry; water is a polar molecule.

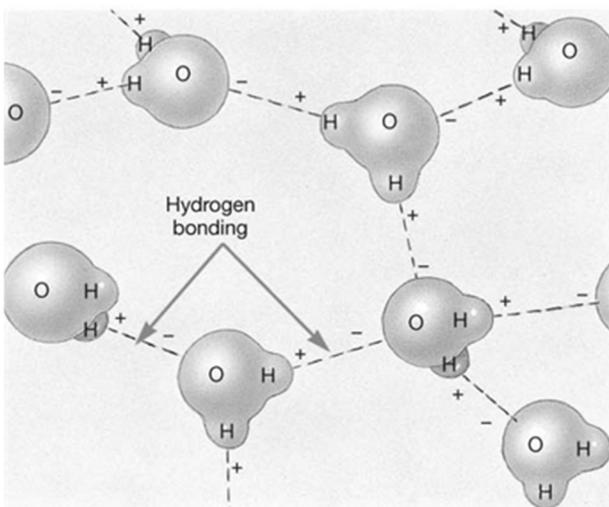


Oxygen has an electronegativity value of 3.4  
Hydrogen has an electronegativity value of 2.2  
That means that the oxygen “gets” the electrons from hydrogen most of the time, leaving the molecule with TWO POLES, oxygen is the negative pole, and hydrogen is the more positive pole side of the bond (most of the time)

Water makes a super-duper dipole, which creates the hydrogen bonding.

Hydrogen bonding comes from polar bonds containing hydrogen atoms ( $\text{H}_2\text{O}$ ,  $\text{NH}_3$ ,  $\text{HCl}$ , etc. exhibit hydrogen bonding).

The diagram below shows these molecular dipoles, that are strongly attracted to each other. The strength of this hydrogen bonding is pretty strong, and hydrogen bonding causes the properties of water.



Hydrogen bonds between a group of water molecules is shown on the left.

These bonds account for most of the MAIN properties of water, such as...

## 1. SURFACE TENSION

The molecules bond tightly to each other, but not to the air. These bonds create a tightness on the surface of water, that actually has the strength to hold denser particles from breaching the edge. In lab we saw sulfur powder (density of  $2.00 \text{ g/cm}^3$ ) float on the surface of water; the sulfur could not break through the surface - until we added soap, which is a **surfactant**.

Surfactants interfere with hydrogen bonds as their molecules get between the water molecules, creating tiny holes in the surface. Soap created an easy way for the sulfur to break through the surface, and then sink through the water to the bottom of the beakers.



Soap is a surfactant; the soap molecule is pretty big ( $\text{NaO}_2\text{C}_{18}\text{H}_{35}$ ). Part is soluble in water, but the long tail is nonpolar and is insoluble in water. It can only partly dissolve in water. Part of the soap doesn't dissolve in water. Strangely it's nonpolar/insoluble in water on one side and ionic/partly soluble on the other side. Soap is molecular and ionic at the same time (cool and weird!).

When soap partly dissolves, the nonpolar part blocks water molecules from forming hydrogen bonding at the surface, creating gaps in the surface of water. These are "HOLES" in the surface, they allow sulfur, or bugs to fall through the surface. Soap breaks surface tension by interfering with the strong, side to side hydrogen bonding normally found at the surface edge of water. It makes holes in the surface.

Surfactant = SURFACE ACTIVE AGENT. Soap is a great example of a surfactant.

## 2. HIGH SPECIFIC HEAT CAPACITY

In table B in our reference tables it shows us that the specific heat capacity constant for water is  $4.18 \text{ J/g}\cdot\text{K}$ . This means to raise the temperature of ONE GRAM of water by ONE KELVIN, it takes 4.18 JOULES of energy. Joules are fancy energy units, but  $4.18 \text{ Joules} = \text{ONE calorie}$  (small "c" calories).

$1000 \text{ calories} = 1 \text{ Calorie}$  (capital "C" Calorie = kilocalorie) also known as a food calorie. To increase the temperature of water requires the water molecules move faster. To move faster they must overcome their strong attractions to one another, those attractions are the hydrogen bonds. These hydrogen bonds are strong enough to make water require much more energy to increase in temperature than most other substances. The specific heat of Fe is only  $0.46 \text{ J/g}\cdot\text{K}$ , and for Hg it's only  $0.14 \text{ J/g}\cdot\text{K}$ .

## 3. LOW VAPOR PRESSURE (low evaporation rate)

When a liquid is in a SEALED container, some of the liquid will evaporate. The gas pressure created by the evaporated liquid exerts extra pressure, called the vapor pressure. Water has low vapor pressure, because of hydrogen bonding. Water does not evaporate well, it doesn't want to let go of itself, and so it mostly stays in the liquid phase. To evaporate, molecules must gain enough kinetic energy to overcome the air pressure from above - as well as the attractions of the intermolecular hydrogen bonding.

In the open air, water will evaporate, but it evaporates much slower than most other liquids that don't have hydrogen bonding. Rubbing alcohol and gasoline evaporate much more quickly than water does.

#### 4. High Boiling Point

For the same reason of hydrogen bonding causing the water to stick together as a liquid, making evaporation slower, boiling point is also impacted the same way. For water to boil, ALL the water molecules must gain have enough kinetic energy to get up to the boiling point.

Once the water gets heated up to  $100^{\circ}\text{C}$  or  $272\text{ K}$ , it then takes more energy, the heat of vaporization =  $2260\text{ J/g}$  too. .

As water absorbs this energy, it boils. The bubbles in boiling water are water in the gas phase,  $\text{H}_2\text{O}_{(\text{G})}$ . Water molecules that have gained so much energy are able to blow apart from the liquid phase into a gas. Gas is LESS DENSE, they form into the bubbles which we see as water boils.



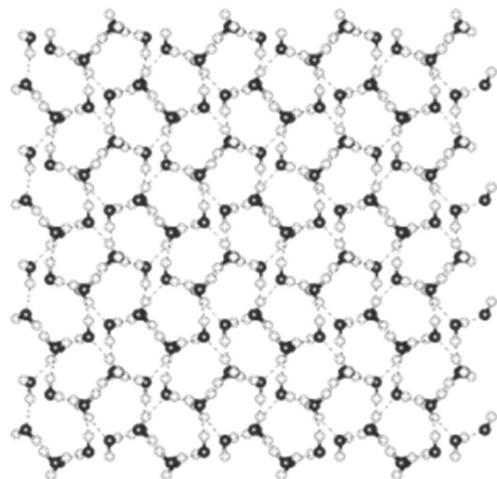
#### 5. The Density of Ice is LOWER than the density of liquid water

When the kinetic energy of water decreases, the temperature of the water drops, the water feels colder. At a certain point ( $0^{\circ}\text{C}$  and  $101.3\text{ kPa}$ ) the liquid water becomes solid ice. The water molecules slow down so much that the hydrogen bonds are now strong enough to lock them together and force them into a stable complex of six-molecule hexagon shaped rings. These rings of water molecules are held together by hydrogen bonds in three dimensions. Solid ice forms. The six-molecule rings have a small gap - and this gap, which takes up space, creates an unusual situation: the SOLID ice has a LOWER DENISTY than liquid water.

To melt ice, you add  $334\text{ J/g}$  (the heat of fusion). To melt it you don't have to break every single hydrogen bond, just loosen them enough to let the molecules flow over each other.

If you make the classic error and draw a water molecule in a straight line, I will tease you and tell you that if that were the case - if water molecules were nonpolar due to their shape; there would be no life on Earth. That's true, and worth explaining.

Water freezes with the gap in the center of every six molecules. Six frozen water molecules take up more space than six liquid water molecules. That tiny space allows  $\text{H}_2\text{O}_{(\text{S})}$  to be less dense than  $\text{H}_2\text{O}_{(\text{L})}$ . The difference is small, but sufficient to let ice float on water.



Most solids will sink in their own liquids. Solid copper sinks in melted copper, solid lead sinks in liquid lead. If solid ice were able to sink into liquid water over a period of years so much ice would sink into the oceans and deep lakes, all the water on Earth would end up frozen. Except in the summers, when ice on the surface would melt, but then it would refreeze in the winter. This would kill all water life, most importantly the algae, which convert carbon dioxide into oxygen. All life on Earth would perish too. Be happy water is a bent, polar molecule.

ABOVE... Frozen water molecules arranged in their normal hexagonal shape.

Note the holes in each hexagon, they create more volume than 6 molecules have as liquid.

Liquid water is more dense than solid water.

The diagram appears flat, note that ice has this pattern in three dimensions.

## 6. The Solvation process and Electrolyte Formation

When polar compounds get dissolved into water, the concept of LIKE DISSOLVES LIKE comes to mind. Solvation is the science word for dissolving into solution. Water is a POLAR MOLECULE, which means it has a positive and a negative side (hydrogen side and the oxygen side). The water molecules “gang up” on the ions, or polar molecules, orienting themselves around the charged particles according to opposite charges.

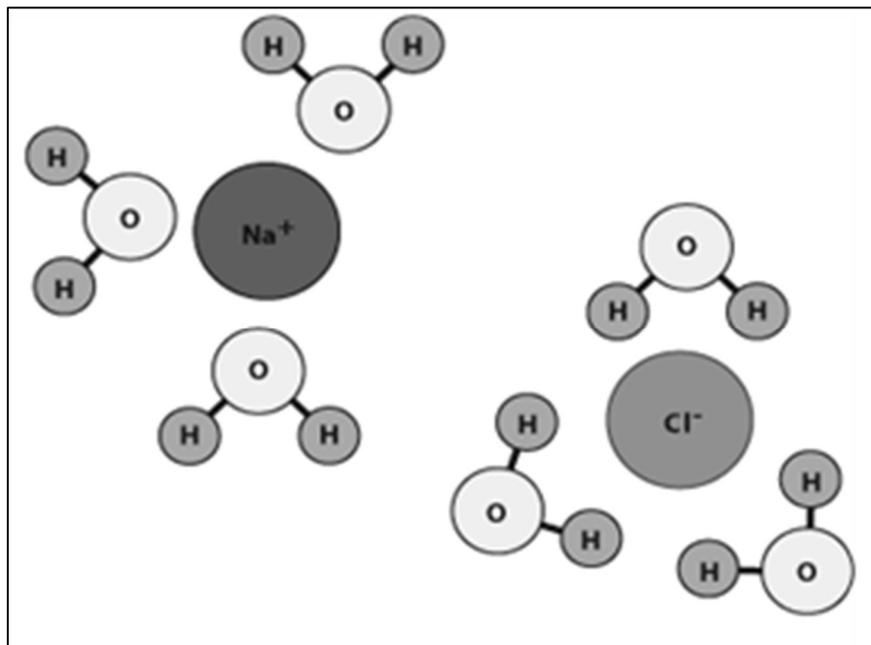
For ionic compounds, the formula units are broken up into cations and anions, again the water molecules arrange themselves around each ion, the positive and negatives set the positioning.

In this picture...

Water orients itself to the ions of NaCl, and the water is able to “carry” the ions in solution.

We see the  $\text{Na}^{+1}$  cations surrounded by the oxygen side of water. And we see the  $\text{Cl}^{-1}$  anions surrounded by the positive side of water, hydrogen.

The water “attacks” ionic compounds, pulling ions off from the solid. At some point the water molecules are all “BUSY” surrounding the cations and anions. At that point the water is SATURATED with salt. If more salt is added, it cannot stay in solution because ALL the water molecules are busy.



When ionic compounds dissolve into water, it forms into ions. That process is called ionization or dissociation. The loose ions in the solution allow it to conduct electricity. The solution is called an ELECTROLYTE. Electrolytes are ionic aqueous solutions with loose ions that can conduct electricity. Electrolytes are also ionic compounds that WOULD form aqueous ionic solutions even though as solids they can't conduct electricity. When a solid ionic compound is put into water, it dissolves. This is NOT a chemical reaction; it is a phase change from solid  $\rightarrow$  aqueous.

3 examples of ionization or dissociation are:  $\text{NaOH}_{(s)} \rightarrow \text{Na}^{+1}_{(aq)} + \text{OH}^{-1}_{(aq)}$   
 $\text{NaCl}_{(s)} \rightarrow \text{Na}^{+1}_{(aq)} + \text{Cl}^{-1}_{(aq)}$  or  $\text{Mg}(\text{NO})_{3(s)} \rightarrow \text{Mg}^{+2}_{(aq)} + 2\text{NO}_3^{-1}_{(aq)}$

When a solution contains loose mobile ions, the solution is an ELECTROLYTE. That is, it can conduct electricity. The more ions in solution, the better the conductor. The less ions, the worse conductor.

When a molecular compound dissolves in water, it is NOT IONIC, it does not form ions, it's not going to be an electrolyte. It can dissolve because the molecules are polar. Sugar and ethanol (alcohol) dissolve in water, but the solution is not an electrolyte – no ions in solution = no electricity conduction.

They are SOLUTIONS - but they lack loose mobile ions, so they are NOT ELECTROLYTES.

An example of this is sugar dissolving into water  $\text{C}_{12}\text{H}_{22}\text{O}_{11(s)} \rightarrow \text{C}_{12}\text{H}_{22}\text{O}_{11(aq)}$

This is solvation, but it forms loose mobile MOLECULES, not ions, sugar water cannot conduct electricity.

## 7. Water can form HYDRATED IONIC COMPOUNDS

Water can be hydrogen bonded to a variety of ionic compounds. The water is “loosely” bonded (hydrogen bonded) to the ionic compound. We are familiar with several hydrates (hydrated ionic compounds), such as Copper (II) sulfate pentahydrate  $\text{CuSO}_4 \cdot 5\text{H}_2\text{O}$ , it has 5 water molecules hydrogen bonded to the  $\text{CuSO}_4$  salt.

Another compound we used in lab is known commonly as EPSOM SALT, or magnesium sulfate heptahydrate ( $\text{MgSO}_4 \cdot 7\text{H}_2\text{O}$ ). That compound has room for 7 molecules of water to be HYDROGEN BONDED onto it. There are MANY other examples of hydrated ionic compounds as well, like...

Aluminum potassium sulfate dodecahydrate  $\text{AlK}(\text{SO}_4)_2 \cdot 12\text{H}_2\text{O}$

iron (III) chloride hexahydrate  $\text{FeCl}_3 \cdot 6\text{H}_2\text{O}$

potassium fluoride dihydrate  $\text{KF} \cdot 2\text{H}_2\text{O}$

An important one liner in water and solution chemistry is LIKE DISSOLVES LIKE. It refers to the fact that water, which is POLAR, can dissolve polar molecules, but it cannot dissolve nonpolar molecules. Water is polar, it dissolves only polar molecules.

Water also can dissolve most ionic compounds, but NOT ALL OF THEM. That’s why we have table F to look up the exceptions. Ionic compounds are polar; they have a positive pole and a negative pole. They dissolve into water, unless they are too tightly bonded together, in that case they just sink to the bottom, or if they happen to form during a double replacement reaction, they precipitate out as a solid and sink to the bottom of the beaker.

solute	+	solvent	make	products
$\text{NH}_3$	+	$\text{H}_2\text{O}$	→	$\text{NH}_{3(\text{AQ})}$ ammonia is polar
$\text{CH}_4$	+	$\text{H}_2\text{O}$	→	Nothing, $\text{CH}_4$ is nonpolar and does not dissolve into water
$\text{NaCl}$	+	$\text{H}_2\text{O}$	→	$\text{NaCl}_{(\text{AQ})}$ is ionic and aqueous
$\text{C}_{12}\text{H}_{22}\text{O}_{11}$	+	$\text{H}_2\text{O}$	→	$\text{C}_{12}\text{H}_{22}\text{O}_{11(\text{AQ})}$ sugar is polar

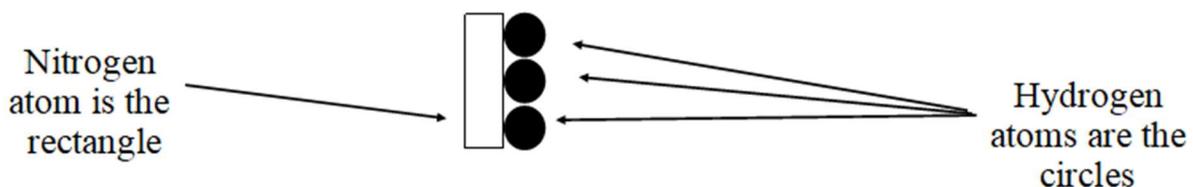
On the next pages there are diagrams that show how a molecular compound like  $\text{NBr}_3$  can dissolve into loose mobile molecules (not ions) in water. It’s a polar molecule, water is polar, like dissolves like.

You’ll see how sodium chloride dissolves into water, but it breaks down into individual cations and anions. Ionic compounds that are aqueous end up as loose mobile ions (salt does not form molecules).

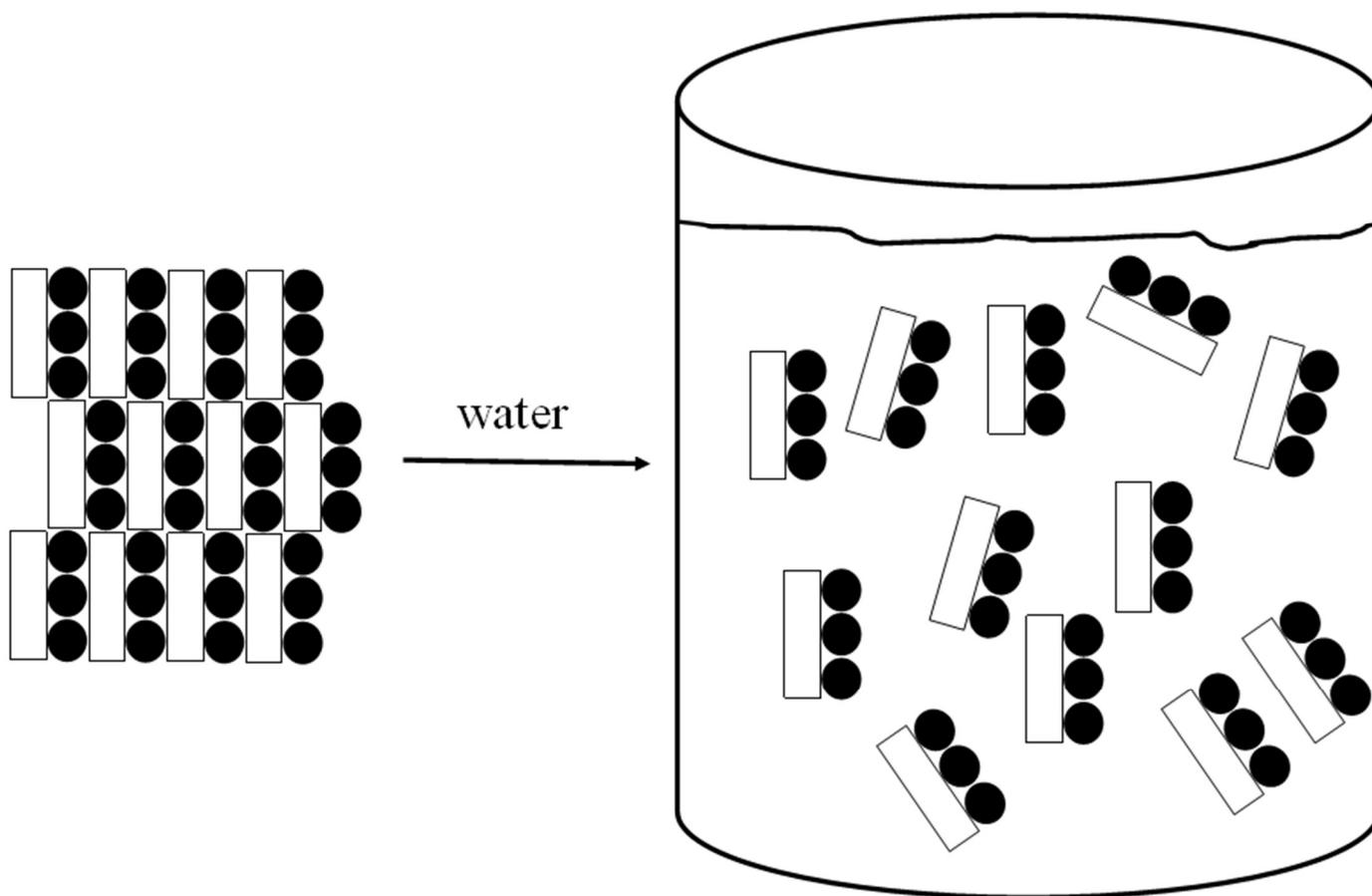
You will NOT see how silver chloride,  $\text{AgCl}$ , or how another compound, calcium phosphate  $\text{Ca}_3(\text{PO}_4)_3$  dissolves into water. Both are ionic, but they are NOT AQUEOUS. They do not form into loose mobile ions. They will just sink in the water.

You also will not see how methane,  $\text{CH}_4$  dissolves into water, it’s molecular but it’s NONPOLAR, and like dissolves like, polar water cannot dissolve this, or any of the HONCIBrIF twins.

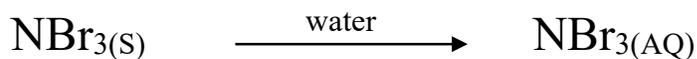
Water can sometimes dissolve small amounts of nonpolar molecules, like oxygen; mostly it’s mixed in, and these small molecules are “sort of lost” and cannot quickly find their way out of the water.



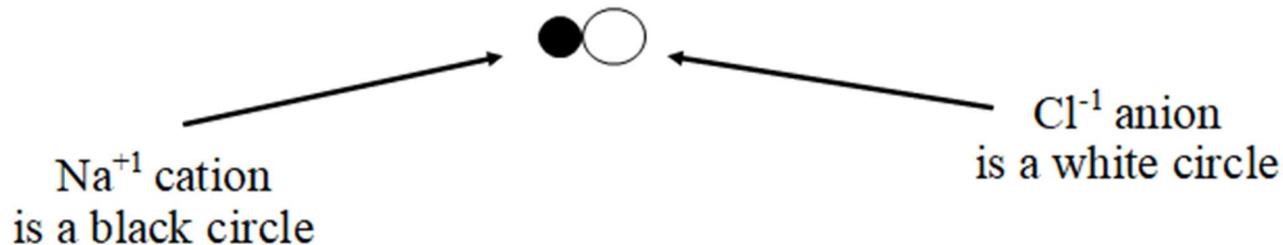
Below, 12 molecules of  $\text{NBr}_3$  are stuck together in the solid phase. When they are put into water, they break apart into smaller and smaller parts, ultimately becoming 12 LOOSE MOBILE MOLECULES,  $\text{NBr}_{3(\text{AQ})}$ . This solution cannot conduct electricity, it has no loose mobile ions, and therefore is NOT an electrolyte.



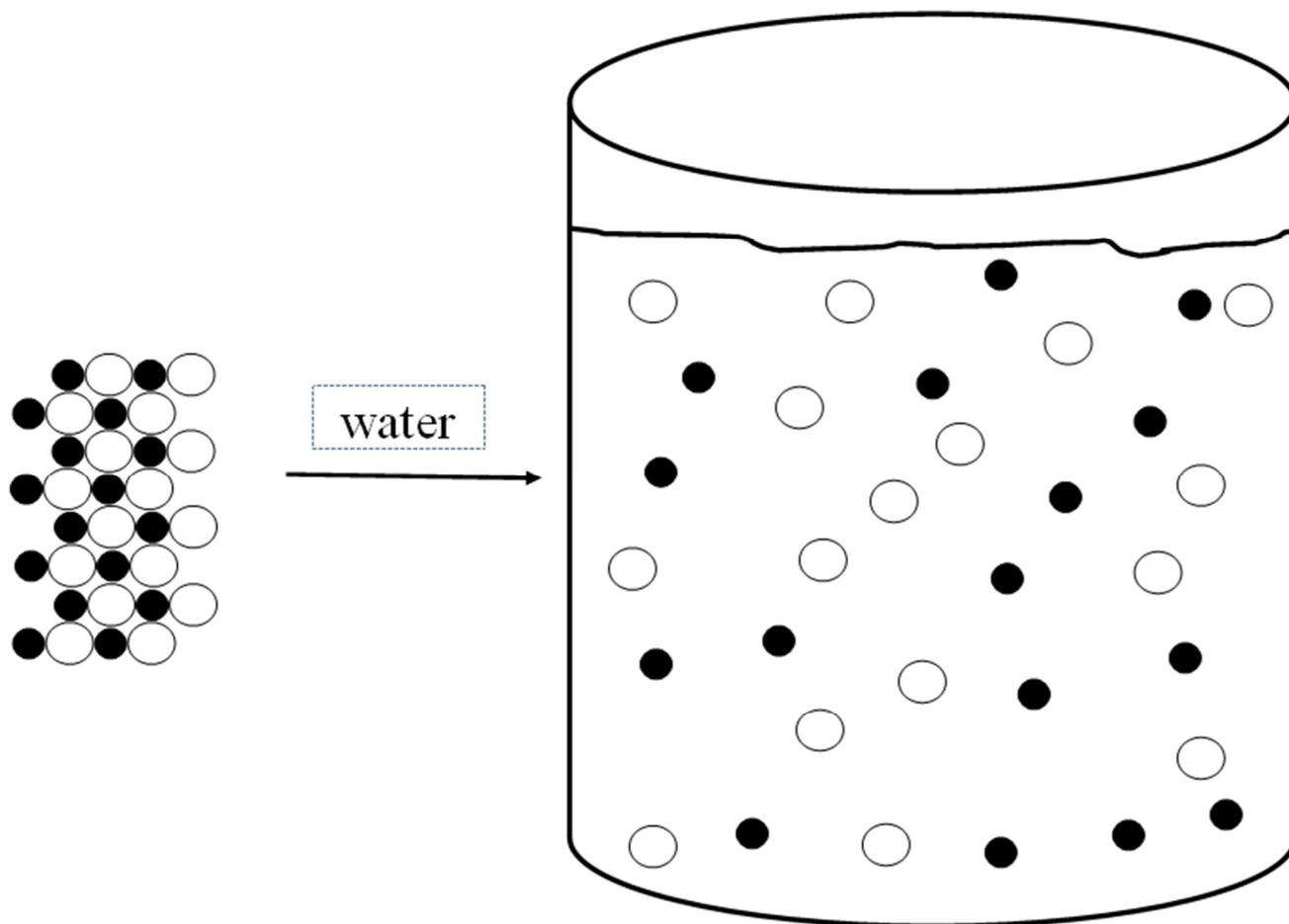
Solid  $\text{NBr}_3$  is added to water, it breaks it up into smaller & smaller particles, called molecules. 1 mole of  $\text{NBr}_3$  forms 1 mole of polar  $\text{NBr}_3$  molecules in water.



No ions form, it's not an ionic compound. It's aqueous because nitrogen tribromide is a polar molecule. It cannot conduct electricity; there are NO loose mobile ions. There are loose mobile molecules, which are not charged like ions are.



Here are 16 formula units of NaCl stuck together in the solid phase. When they are put into water, they break apart into smaller pieces, ultimately becoming 32 LOOSE MOBILE IONS (16 cations, + 16 anions)  
Aqueous  $\text{NaCl}_{(\text{AQ})}$  can conduct electricity, it has loose mobile ions, and it is an electrolyte.



Solid NaCl is added to water, it breaks it up into smaller & smaller particles, called ions.  
1 mole of NaCl forms 2 moles of aqueous ions, 1 mole of  $\text{Na}^{+1}$  cations + 1 mole of  $\text{Cl}^{-1}$  anions.



Loose mobile ions form, it's aqueous and ionic, it can conduct electricity (it's an electrolyte)

## **End Notes, final vocabulary words, etc.**

AQUEOUS means dissolved into water, or that the solvent is water.

MISCIBLE is when 2 or more liquids dissolve into each other, for example: water and alcohol.

IMMISCIBLE is when 2 or more liquids DO NOT dissolve into each other, for example: oil and vinegar.

SOLVENT is what the solute is dissolved into. In salty water, the water is the solvent, salt is the solute

SOLUTE is the stuff dissolved into the solvent. In sugar water, sugar is the solute, water is the solvent.

LIKE DISSOLVES LIKE means that polar solvents like water only can dissolve polar compounds like sugar or most salts. Some salts will not dissolve in water even though they are polar. Further, nonpolar solvents like gasoline or olive oil can only dissolve nonpolar solutes.

DILUTE solutions have small amounts of solute dissolved into the solvent. CONCENTRATED solutions have lots of solute dissolved into the solvent.

SATURATED solutions contain the normal maximum amount of solute that the solvent can hold based upon volume and temperature. (usually hot solutions can hold more solute)

UNSATURATED solutions contain less than the normal maximum amount of solute and can be made more concentrated or stronger by adding more solute.

SUPERSATURATED solutions occur much less often. Most solutions hold certain amounts of solute at certain temperatures. Some compounds can "fool" the solvent into holding more solute than normal if made "hot". The excess solute that should "fall out" of solution doesn't. It stays in solution even though that volume of solvent at that colder temperature SHOULD NOT BE ABLE TO HOLD THAT MUCH SOLUTE. These solutions are unstable and can "crash" - the solute can precipitate out of solution all at once. Table sugar (sucrose) and sodium acetate are common compounds that can supersaturate.

ELECTROLYTIC SOLUTIONS contain loose ions and can conduct electricity. The more loose ions in solution, the better it can conduct electricity (the limits being the saturation points).

NONELECTROLYTE SOLUTIONS do not contain loose ions, for example, sugar water has no loose ions even though the sugar dissolves. Molecular compounds like sugar dissolve into invisible small particles called MOLECULES, not ions. Ionic compounds dissolved into water will dissolve into loose ions. Some ionic compounds, like AgCl are INSOLUBLE in water. If you add AgCl to water, you get solid AgCl at the bottom of the beaker, but no loose ions, so no electrical conduction.

SOLUBLE means able to dissolve. Usually this means dissolving into water, but it can refer to ANY solvent.

INSOLUBLE means cannot dissolve into a solvent, most often water in our high school chemistry course.

PRECIPITATE means a compound that falls out of solution, due to temperature change, or its formation in a double replacement reaction.

## SOLUTIONS

When a solute dissolves into a solvent, a homogenous solution is formed. If the solvent is water, the solution is said to be AQUEOUS. Solutions are homogenous, they are mixed the SAME THROUGHOUT. A given solvent can only hold a certain amount of solute. When it is holding as much as possible, the solution is said to be SATURATED. When the solution has some solute dissolved, but not the maximum amount that could fit, the solution is UNSATURATED.

We can see the amounts of ten different solutes that fit into 100 mL of water at ANY TEMPERATURE by looking at our TABLE G in the reference tables.

To determine the MAXIMUM amount of solute that can fit into 100 mL water at a particular temperature, find the temperature, slide your finger up to the PROPER CURVE. Where they cross is the SATURATION POINT for that temperature. Slide to the left and READ how many grams of solute will fit into the 100mL of water at that temperature.

### How many grams of sodium nitrate fit into 100 mL of aqueous solution at 10°C?

Go to 10°C, then slide your finger up to the  $\text{NaNO}_3$  line. They cross at exactly 70 grams.

That means, 70 g  $\text{NaNO}_3$  forms a saturated 100 mL solution at 10°C.

How much solute fits into a solution is called the SOLUBILITY. Table G shows 10 of these SOLUBILITY CURVES.

Under the curves indicates unsaturated. The curves show the MAXIMUM amount of solute, or the saturation level.

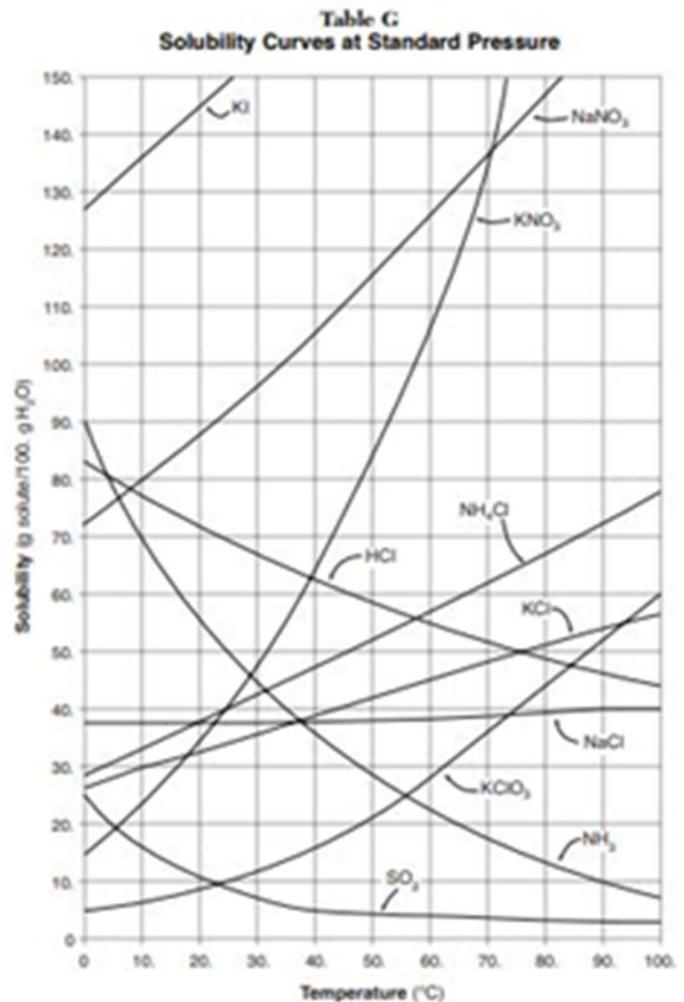
Only 10 compounds are listed on Table G.

Gas solubility generally drops with increasing temperature. As the temperature of the solution increases, the gas expands, making it even less dense. They bubble out quickly.

Gas solubility does INCREASE with increasing pressure. That's how water is turned into seltzer. This is called becoming carbonated. It can happen only under high pressure. When a can of soda or seltzer is opened the carbon dioxide is released because the pressure holding it in solution is lowered when the can opens to the air.  $\text{CO}_2$  is NONPOLAR and it should not dissolve in POLAR  $\text{H}_2\text{O}$ .

LIKE DISSOLVES LIKE, carbonation is not normal.

Soda gets flat when left open to the air. The  $\text{CO}_2$  gas bubbles out of the polar liquid water easily. This is a process though, and depending on the soda's temperature, it can be slow enough that we can enjoy drinking carbonated beverages before they go flat and gets blah.



## Water Notes

Objective: what are the important properties of water, and what is the fundamental reason that they exist?

Additionally, we will learn some new water vocabulary words and review some you should know.

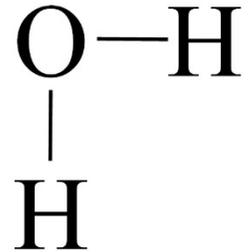
1. A water molecule is \_\_\_\_\_. It does NOT HAVE \_\_\_\_\_

Water molecules are \_\_\_\_\_. Water forms \_\_\_\_\_ bonding due to a great difference in the

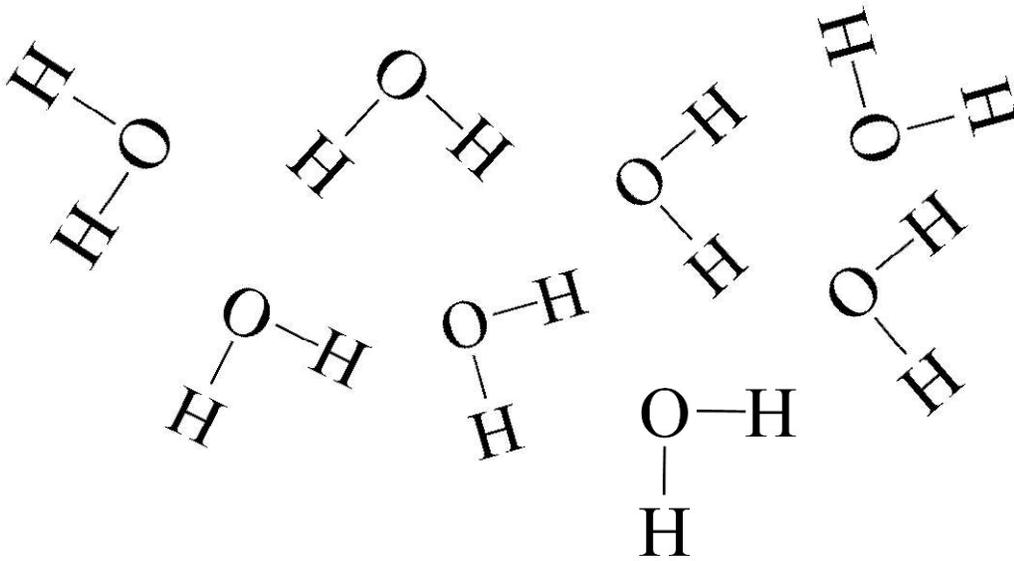
\_\_\_\_\_ values between the oxygen and hydrogen atoms.

The dipole arrows have a + end and an arrowhead that indicates “where” the electrons move towards (higher electronegative atoms)

Draw 2 dipole arrows onto this molecule →



2. Connect the water molecules with proper hydrogen bonding. Use a COLORED PENCIL



3. Define Hydrogen Bonding:

4. Get six red/white water molecule magnets. Red =  
6 molecules of water form into a ring. This shape is called a

White =

6. If you squish the 6 magnets (water molecules) in your hands and move them slowly they take up less space than when in the ring shape.

The density of pure water is \_\_\_\_\_

or you could say it this way as well \_\_\_\_\_

7. The density of ICE must be: \_\_\_\_\_ since ice floats in liquid water.

8. The hole in the ring creates a slightly greater \_\_\_\_\_ for 6 molecules of water frozen into a ring, this space is something that liquid water just doesn't have.

9. Liquid water freezes at what temp? \_\_\_\_\_ or \_\_\_\_\_

10. To melt one gram of ice → one gram of water it would take adding the \_\_\_\_\_ of \_\_\_\_\_

11. For water, that constant is \_\_\_\_\_

12. With an ice cube in your hand, the \_\_\_\_\_

\_\_\_\_\_.

13. Skip this one

14. How many water molecules does it take to form a normal crystal of ice? \_\_\_\_\_

15. How many points does a normal SNOWFLAKE have? \_\_\_\_\_

For real, do you see the connection between #14 and #15? That's important for your life and for when you talk to little kids and your parents. If you share this people will think you to be even brighter than you are. Nice.

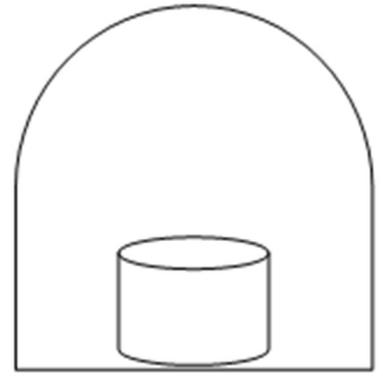
16. Water has a high BOILING POINT. This is due to

Water is hard to boil; there are A LOT of intermolecular \_\_\_\_\_ to overcome.

17. Water has a low VAPOR PRESSURE.

This is due to

Vapor pressure is the extra pressure created by an evaporating liquid inside of a closed system, table \_\_\_\_.



18. Water has SURFACE TENSION.

This is due to



19. Surface tension is...

20. Solid water (ice) can FLOAT on liquid water. This is due to

How many water molecules does it take to form a normal crystal of ice? \_\_\_\_\_

21. Water has a very high SPECIFIC HEAT CAPACITY CONSTANT

This is due to

22. The specific heat capacity constant for water is \_\_\_\_\_

23. Water can form into aqueous SOLUTIONS. This is called \_\_\_\_\_

This is due to

24. \_\_\_\_\_

25. This means that \_\_\_\_\_  
or (most) ionic compounds.

Or...

26. Oils and other \_\_\_\_\_  
(but not water which is polar)

27. Water has the ability to form HYDRATED IONIC COMPOUNDS.

This is due to

28. Examples of hydrated ionic compounds include \_\_\_\_\_ & \_\_\_\_\_

29 Vocabulary	Correct choice	Definitions
Solvation		A. unable to dissolve, (precipitates)
Solute		B. the part of the solution that solute dissolves into (the water part)
Solvent		C. the process of dissolving into a liquid
Aqueous		D. able to dissolve
Soluble		E. holding as much solute in solution as possible (Charlie choc. milk)
Insoluble		F. dissolves into the solvent in a solution (the salt in salty water)
Saturated		G. holding less solute in solution than is possible (Janet choc. milk)
unsaturated		H. dissolved in water

Objective: Mastering Table G – the Solubility Curves for 10 Compounds. Take it out now.

30. For salty water, the solute is the \_\_\_\_\_, the solvent is the \_\_\_\_\_

31. For chocolate milk, the solute is the \_\_\_\_\_, the solvent is the \_\_\_\_\_

32. Table G is titled: \_\_\_\_\_ at standard pressure

Standard pressure is \_\_\_\_\_ or \_\_\_\_\_

33. The Y axis (up/down) is solubility in units of \_\_\_\_\_

34. Which really means this \_\_\_\_\_

35. The X axis has these units \_\_\_\_\_

36. How many grams of KCl fit into 100 mL of water at 10°C? \_\_\_\_\_ grams

37. How many grams of KClO<sub>3</sub> fit into 100 mL of water at 40°C? \_\_\_\_\_ grams

38. How many grams of potassium nitrate saturates 100 mL of solution at 50°C? \_\_\_\_\_ grams

39A. How many compounds are on this graph? \_\_\_\_\_

39B. How many lines go “up” as the temperature rises? \_\_\_\_\_

39C. How many lines go “down” as the temperature rises? \_\_\_\_\_

39D. How many of the compounds are IONIC? \_\_\_\_\_

39E. How many compounds are MOLECULAR? \_\_\_\_\_

40. How do we make sense of these statements???

Ionic compound solubility \_\_\_\_\_

Molecular compound solubility in water \_\_\_\_\_

41. How many lines can you look at on this graph at any time? \_\_\_\_\_

42. When an ionic compound like KI or NaCl goes into water, what particles end up in the water?

\_\_\_\_\_

43. When something like sugar  $C_{12}H_{22}O_{11}$  go into water, what particles end up in the liquid water?

\_\_\_\_\_

44. How many g of  $NH_3$  fit into 100 mL of water at  $90^\circ C$ ? \_\_\_\_\_

45. When water (or any solvent) holds the maximum amount of solute at a given temperature,  
this solution is said to be \_\_\_\_\_ like:

46. How many grams of ammonia fit into 50 mL of water at  $90^\circ C$ ?

47. How many grams of KCl fit into 100 mL of water at  $10^\circ C$ ? \_\_\_\_\_ grams

48. How many grams of KCl fit into 350 mL of water at  $10^\circ C$ ? do math here

49. How many grams of  $NH_3$  fit into 100 mL of water at  $10^\circ C$ ? \_\_\_\_\_ grams

50. How many grams of  $NH_3$  fit into 12.0 mL of water at  $10^\circ C$ ? Show your work

51. How many grams of  $\text{KClO}_3$  solute fits into 844 mL of water at 373 Kelvin? (show work)

52. How many grams of sodium nitrate will it take to saturate 64.0 mL of water at 283 Kelvin?

### Water Class #3

Draw arrows to point to the oil and water in the picture.

53 OIL

54. WATER



55. They do not mix because \_\_\_\_\_

56. In this case the OIL is \_\_\_\_\_

and WATER is \_\_\_\_\_. THEY ARE \_\_\_\_\_

57. The reason that the oil is ON TOP and not on under the water is that the oil

\_\_\_\_\_

A box of biscuits. A box of mixed biscuits, and a biscuit mixer. ☺

58 Immiscible: \_\_\_\_\_  
like water and oil. Water is polar, oil is nonpolar.

59 Miscible: \_\_\_\_\_  
like vegetable oil and olive oil (both nonpolar) — *or water and ethyl alcohol (both polar)*

60. When a solution holds the most solute possible in the solvent it is said to be \_\_\_\_\_

61. If the solution holds LESS than that maximum amount of solute, it's called: \_\_\_\_\_

62. Charlie Chocolate milk would be \_\_\_\_\_

while Janet Chocolate milk is \_\_\_\_\_

63. A 100 mL  $\text{HCl}_{(\text{AQ})}$  at  $80^\circ\text{C}$  contains 37 g of HCl. Is this saturated or unsaturated? (circle one)

\_\_\_\_\_

64. Is a 100 mL  $\text{NaNO}_{3(\text{AQ})}$  at  $25^\circ\text{C}$  saturated if it contains 93 g  $\text{NaNO}_3$ ? YES or NO (circle one)

\_\_\_\_\_

65. How many grams of NaCl will saturate a 100 mL solution at  $90^\circ\text{C}$ ? \_\_\_\_\_ grams

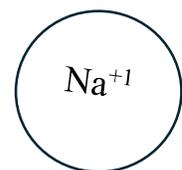
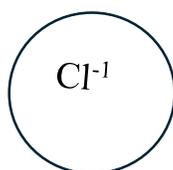
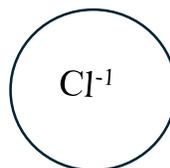
66. If you put 43 g NaCl into 100 mL, what would happen?

67. Will a 100 mL  $\text{NaCl}_{(\text{AQ})}$  at  $90^\circ\text{C}$  be saturated if it contains 43 g NaCl? \_\_\_\_\_,

$\text{NaCl}_{(\text{S})}$

😊	Temp	Solute	If a solution contains this Mass in g	Saturated or Unsaturated?	If unsaturated, how many more grams are needed to saturate this solution?
69	30°C	HCl	60 g		
70	60°C	KNO <sub>3</sub>	100 g		
71	10°C	NaNO <sub>3</sub>	80 g		
72	90°C	NH <sub>4</sub> Cl	73 g		
73	20°C	KCl	20 g		
74	5°C	NaCl	31 g		

75 Arrange water molecules around these loose mobile ions of sodium chloride that have ionized into water



76. Explain in one sentence why the water molecules are going to orient themselves to the ions in solution.

## Surfactants

77. Soap is a surfactant. It can break the \_\_\_\_\_

78. Surfactant = \_\_\_\_\_

79. Soap is partially \_\_\_\_\_ + partially \_\_\_\_\_

80. The polar “head” gets dissolved in water; the

---

This allows water to escape “out of” the surface, or stuff to “fall through” the surface of the water.

81. \_\_\_\_\_ create gaps in the surface hydrogen bonding.

82. Oil molecules (vegetable oil, motor oil, mineral oil, etc.) are all nonpolar.

When oil is put into water, why can't the oil dissolve into the water like salts, or polar sugar molecules?

Because \_\_\_\_\_ the water is polar, the oil is nonpolar. The water “can't catch” the oil droplets, they slip through the water's grasp

The oil floats because oil has \_\_\_\_\_ than the water.

83. How many grams of  $\text{KClO}_3$  saturates 100 mL of water at  $90^\circ\text{C}$ ? \_\_\_\_\_

84. How many grams of  $\text{KClO}_3$  saturates 100 mL of water at  $40^\circ\text{C}$ ? \_\_\_\_\_

85. If you have a saturated  $\text{KClO}_3(\text{AQ})$  at  $90^\circ\text{C}$  and put it into a cooler, the temperature drops to  $40^\circ\text{C}$ , what could possibly happen to all that  $\text{KClO}_3$  that was in solution?

86. A 100 mL saturated solution of  $\text{KNO}_3$  is at  $60^\circ\text{C}$  is cooled to  $20^\circ\text{C}$ . Describe what happens. Do math.

The rate of \_\_\_\_\_ = The rate of \_\_\_\_\_

**This is dynamic equilibrium**

### The last water class...

87. What happens when you put 140 g KI into 100 mL water at  $10^\circ\text{C}$ ?

88. Does this "STOP"? \_\_\_\_\_

89. What does happen?

Label this picture.

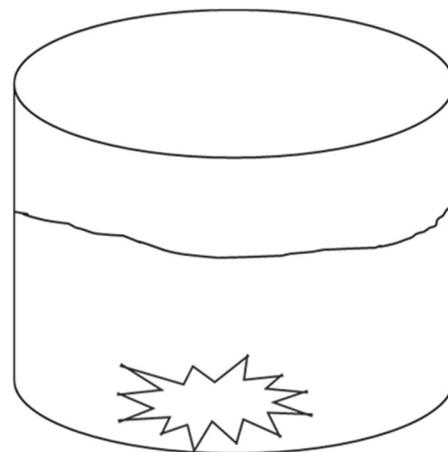
90. \_\_\_\_\_

91. \_\_\_\_\_

92. In a \_\_\_\_\_,

the rate of the \_\_\_\_\_ reaction is

equal to the rate of the \_\_\_\_\_ reaction.



93. In this case we could say that the

**rate of  
SOLVATION**



**rate of  
PRECIPITATION**

94.  $\text{NaCl}_{(s)} \rightarrow \text{Na}^{+}_{(aq)} + \text{Cl}^{-}_{(aq)}$  this is called \_\_\_\_\_ or \_\_\_\_\_

95. Does sugar,  $\text{C}_{12}\text{H}_{22}\text{O}_{11}$  do this? \_\_\_\_\_ How does sugar dissolve into water?

**96. Electrolytes** To be an electrolyte, a compound must be \_\_\_\_\_ & \_\_\_\_\_

This provides \_\_\_\_\_ in solution

Loose mobile ions conduct \_\_\_\_\_

IONIC but NOT AQ is \_\_\_\_\_ (ex: AgCl or CuS)

AQ but not IONIC is \_\_\_\_\_ (ex: sugar water)

☺	Substance	Is this an electrolyte?	Will this conduct electricity?
97	$\text{NaCl}_{(aq)}$		
98	$\text{NaCl}_{(s)}$		
99	$\text{NaOH}_{(aq)}$		
100	$\text{NaOH}_{(s)}$		
101	$\text{AgCl}_{(aq)}$		
102	$\text{AgCl}_{(s)}$		
103	$\text{C}_{12}\text{H}_{22}\text{O}_{11(aq)}$		

104. Is  $\text{Be}(\text{OH})_2$  an electrolyte? \_\_\_\_\_ Can it conduct electricity? \_\_\_\_\_

105. What about  $\text{Be}(\text{OH})_{2(\text{L})}$  (melted beryllium hydroxide), will that be able to conduct electricity? \_\_\_\_\_

106. How is that possible?

107. If liquid  $\text{Be}(\text{OH})_2$  can conduct electricity, is it an electrolyte? \_\_\_\_\_, because

108. When sodium chloride goes into water, we would write the "equation" this way:



109. This is called \_\_\_\_\_ or \_\_\_\_\_

110. Does sugar do this? \_\_\_\_\_ What does sugar do?

Sugar \_\_\_\_\_.

Sugar is NOT IONIC, it dissolves because the molecules are \_\_\_\_\_,

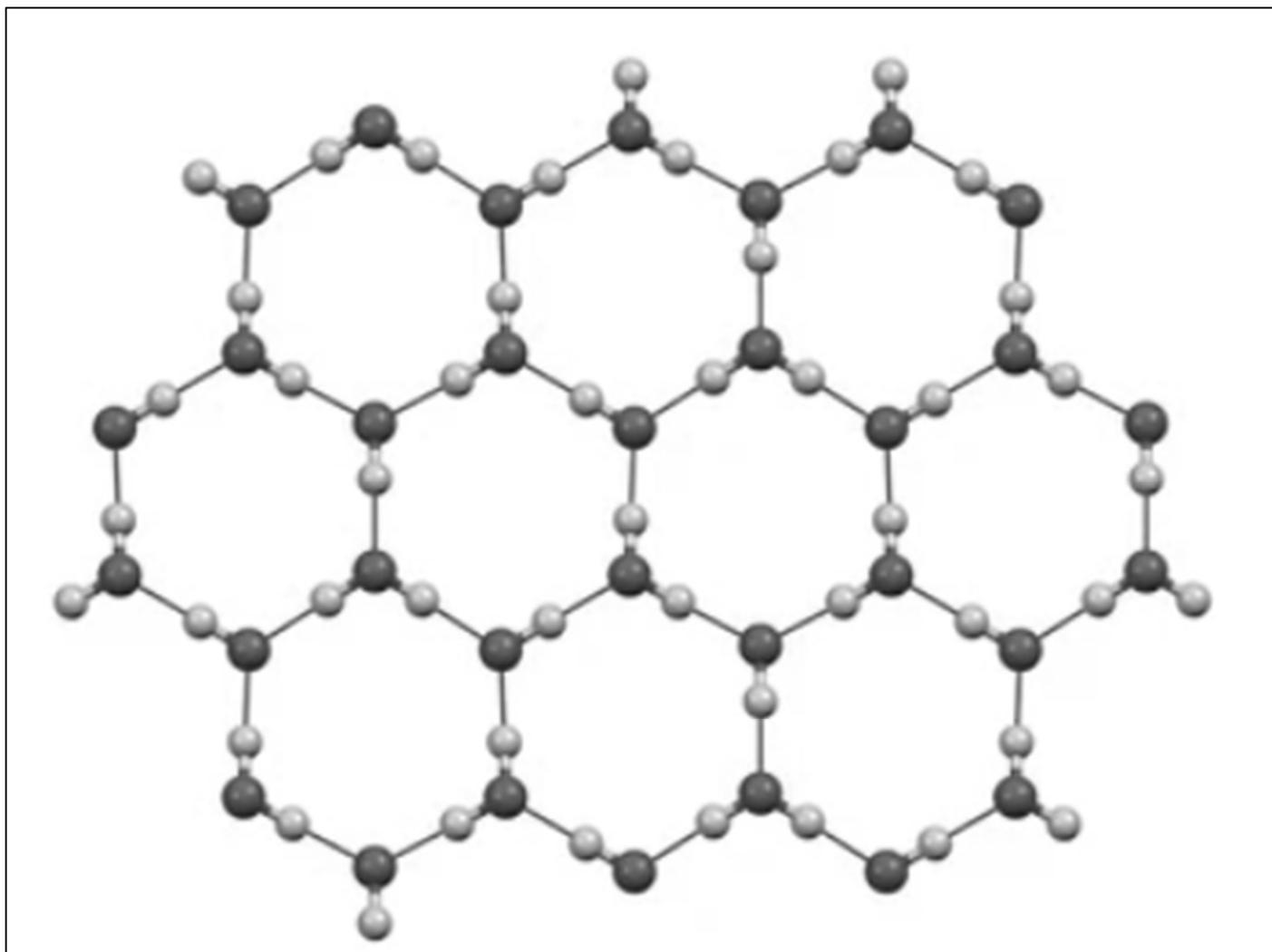
but it dissolves into \_\_\_\_\_.

111. Show the dissociation or the ionization for sodium nitrate in water with phase symbols:

\_\_\_\_\_

112. Show the dissociation or the ionization for potassium phosphate in water with phase symbols

\_\_\_\_\_



In this picture of ice, find the H<sub>2</sub>O molecules. A few of these molecules seem to have just 2 atoms, that is because the third atom is going backwards, “into” the page, and it hidden in this flat view.

Hydrogen bonding is caused by bond polarity containing hydrogen atoms bonded to other atoms with a much higher electronegativity, making the H atoms positive and the “other” atoms more negative. Here it is the oxygen atoms that are negative and the hydrogen atoms that are positive.

These two “poles” attract together molecule to molecule. When water temperature decreases as the water gets colder, the kinetic energy of the molecules decreases. At the freezing point, the kinetic energy is so low that the hydrogen bonding between molecules locks the water molecules into the simple hexagon rings. The rings grow in all directions (three dimensions).

Six water molecules have mass of 108 AMU (water is 18 AMU/molecule). When they are in the liquid phase, water has density of 1.0 g/mL. Six molecules of water in the solid phase will have a slightly greater volume (that little gap in the center takes up space) the same six molecules will have a slightly lower density, which is about 0.93 g/mL

This allows ice to float on water, which is an unusual characteristic for a solid to be able to float in its liquid.