Take-Home Messages

- Interesting phenomena can stimulate a rich variety of questions.
- Questions drive the investigation process.
- Questions can either be investigable or noninvestigable.
- Noninvestigable questions can be turned into investigable ones.

Criteria For Investigable Questions

Criteria for Investigable Questions

Safety
Time allocated for activity
Resources/materials available
Is it measurable?
Vested interest/motivation/ownership
Prior knowledge
Objectives/expectations/TEKS
Grade level appropriate/challenging

Non-investigable Questions

What were the hair-like structures inside the ice?
How did the bubbles get inside?
If the liquid is changed will it affect the bubbles? Will turbulent water or liquids with bubbles affect the bubbles?
Why was the balloon already broken?
How do different materials hold up during the freezing process?
Would the balloon still pop if we filled it with vodka?
Why was the outer edge clear and inner part cloudy?
Would different waters create the same clear and cloudy effect?
Does the temperature at which we freeze the ice affect the size of the cloudy area?
Will different liquids form the same bubble structure?
How does the initial temperature of the water affect the freezing?
What caused the crack?
Why are the spiny things radiating outwards?
What is the food coloring made of that allows it to melt the ice?
How long will it take to melt the ice balloon in the water vs. the tray?
If you added salt to the water how would it affect the time it takes to melt?

Investigable Questions

How did different substances affect the temperature of the ice?
How did putting different substances on the nail or ice pick help them cut through the ice?
Can we drill a hole through the ice with salt?
Why does the ice ball move in the water?
How does the temperature of the water change when the ice balloon is placed inside?
Will the food coloring solidify?
What are the fuzzy things?
Why does the cloudy part of the ice seem more dense?
What would a laser do to the ice?
How would the light refract differently if the shape of the balloon was altered?
Will the salt melt all the way through?
How long will it take to melt? Or to freeze?
What kind of crystal is put on the ice?
Why does the food coloring have more capillary action on one side than the other?

Turning Questions: A Variables Scan

The situation . . .

- Second grade students are exploring how paper towels absorb water.
- They notice that paper towels seem to “suck up” the water.
- Someone asks, “Why does the water go into the paper towel?”

Turning Questions: A Variables Scan

The Scan . . .

- When you "scan" the situation, what variables can you find?
- The explanation must have something to do with how the *water* and the *paper towel* interact, so those are the variables we can change to help us learn more.

"WHY DOES THE WATER GO INTO THE PAPER TOWEL?"

The Variables . . .

1. Water (or other liquid)
2. Paper towel (or other material)

Turning Questions: A Variables Scan

Turning the Question . . .

■ How can the question be turned into practical action?

CONSIDER VARIABLE 1: The liquid being absorbed. What could be changed about the liquid?

- The kind of liquid (tomato juice, motor oil, etc.)
- The amount of liquid
- The temperature of the liquid

"WHY DOES THE WATER GO INTO THE PAPER TOWEL?"

Turned Questions . . .

- Would something different happen if the water were very hot or very cold?
- Would salt water be different from fresh water?
- Would something different happen if we used tomato juice?

Turning Questions: A Variables Scan

Turning the Question . . .

- How can the question be turned into practical action?

CONSIDER VARIABLE 2: The material absorbing the liquid. What could be changed about the paper towel?

- The brand of paper towel
- The wetting procedure (pouring the water onto the paper, dipping the towel into the water, etc.)
- The kind of material (cotton, wool, cardboard, etc.)

"WHY DOES THE WATER GO INTO THE PAPER TOWEL?"

Turned Questions . . .

- Does the brand of paper towel make a difference?
- What happens if typing paper is used?
- Does cotton cloth "suck up" water?
- What happens if you stick only the corner of a paper towel in the water?

CONTENT

Bubble Formations

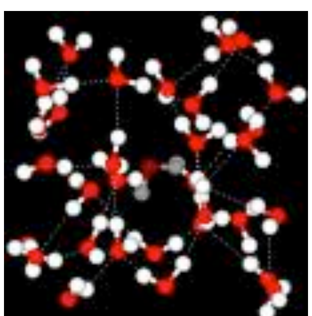
- Water freezes from outside in
- Impurities and air bubbles are pushed toward center
- Long spikes (spicules) are long skinny bubbles of air
- Light scatters due to bubbles
- Refraction due to different density, cracks, etc
- Refraction vs Reflection

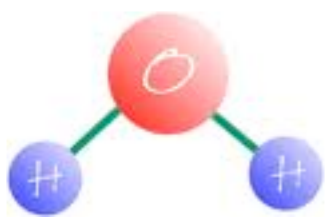
Energy/Phase Change

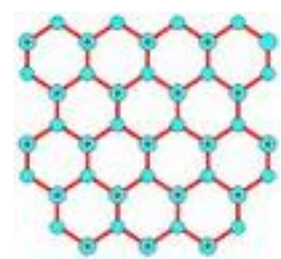
- Energy flows to cold ice from warmer substance until it reaches 0°C.
- As it melts, temperature remains the same (phase change)
- As ice melts, it melts throughout all crystal boundaries creating vacuum and pulling in air and collapses. "White" ice is not safe.
- Transfer of heat depends on many factors including conduction, surface area, thermal conductivity, temperature difference, heat capacity, mechanical "factors"

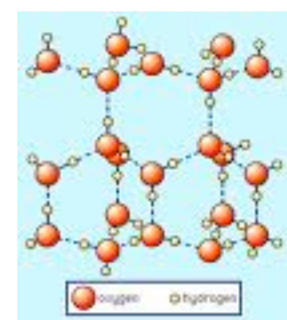
Density

- Most substances are more dense as solids; therefore have less volume and more density
- Ice crystals are open, 6-sided structures where molecules are farther apart than water.
- Maximum density at 4°C









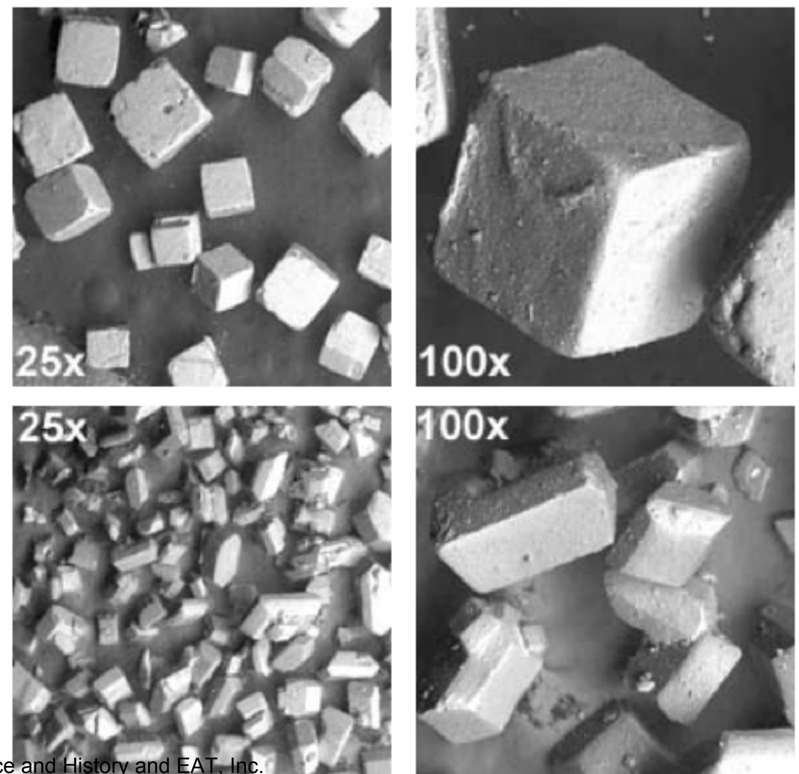
- Solutes dissolved in water will lower the freezing temperature by amount proportional to number of dissolved particles
- Freezing point lowered according to structure of solute. Sugar has 45 atoms and salt only has 2 ions so 1 tsp of salt has more particles (to interact) than 1 tsp of sugar. Salt ions also break up when dissolved which gives twice as many particles to interfere.
- In sugar, bonds form in a variety of locations which makes irregular shapes.Sugar's bonds form chains between atoms, then the chains bond in geometrically irregular ways
- Table salt's visual appearance is much more readily predictable because of its molecular structure. Its chemical bonds are structured so that each piece of salt "looks" the same no matter where you look —like a cubic rectangular prism

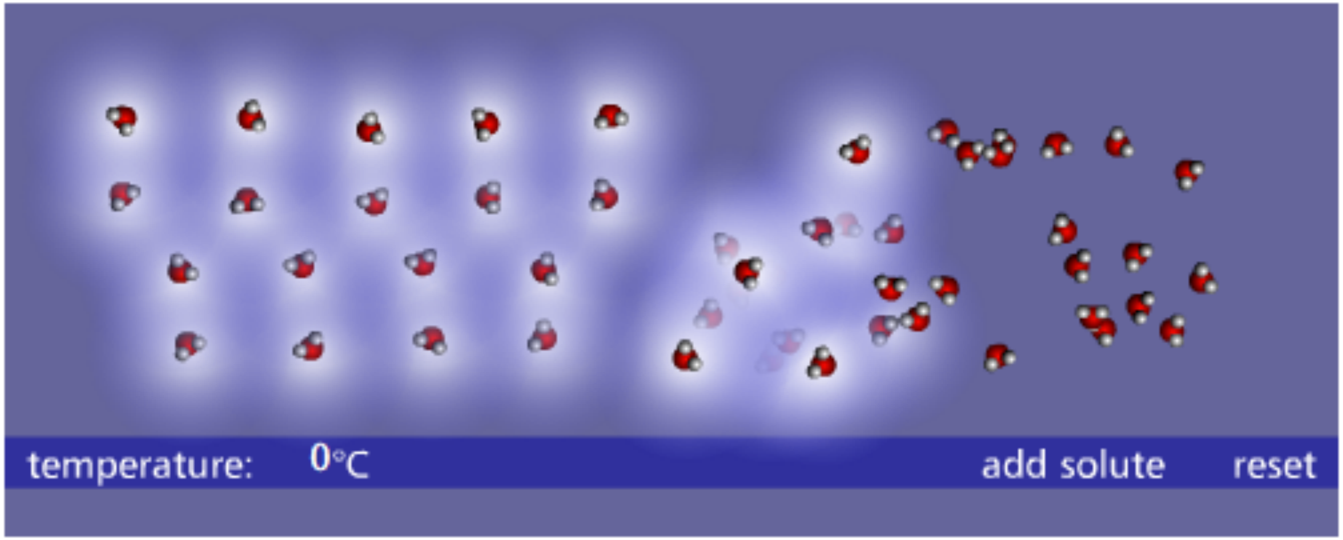
NSTA: Salt and Sugar Investigation

» http://www.nsta.org/publications/news/story.aspx?id=48629

SEM images of salt crystals at low and high magnification

SEM images of sugar crystals at low and high magnification

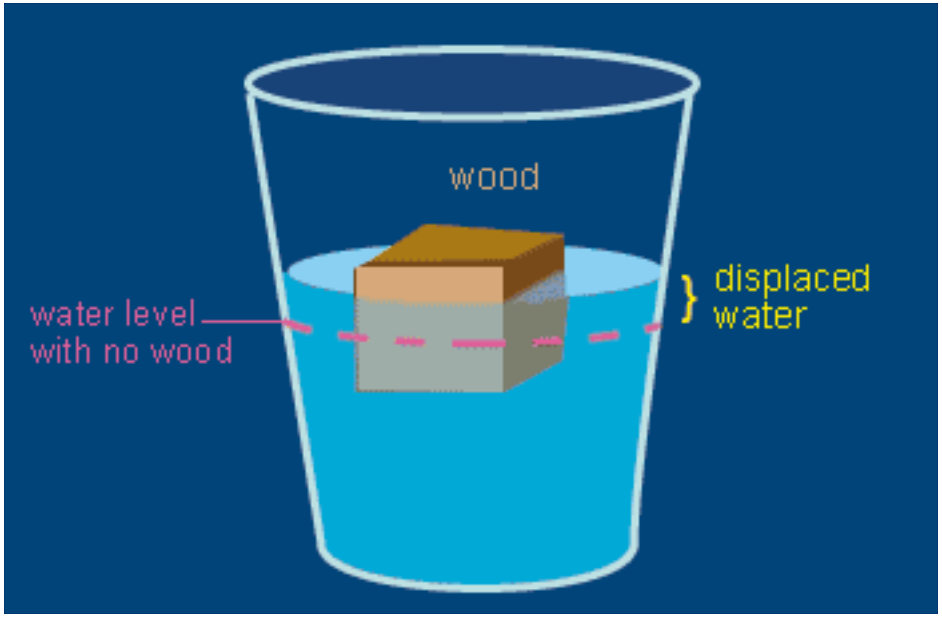




- Salt and freezing process animation. As temperature drops, molecules move more slowly and are more likely to be captured by the ice. As they are heated, they move faster and are more likely to escape.
- Adding salt reduces the number of water molecules on liquid side (concentration) so total amount of water molecules captured by the ice is reduced, so freezing rate goes down (not in equilibrium). Rate of melting is unchanged so melting occurs faster than freezing
- There is balance between freezing and melting at 0 degrees C.
- To re-establish, you must cool ice-saltwater mixture below normal melting point (freezing point depression). Higher concentration salt = greater freezing point depression.

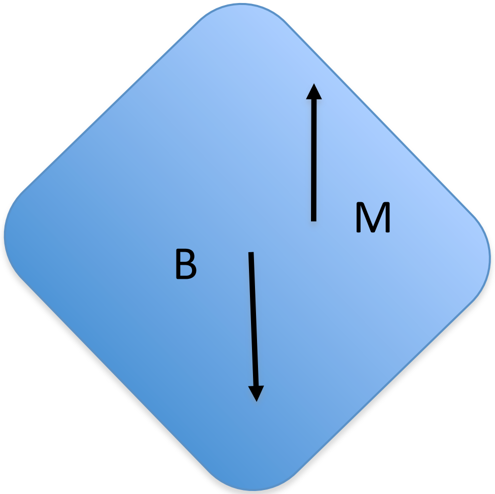
Buoyancy

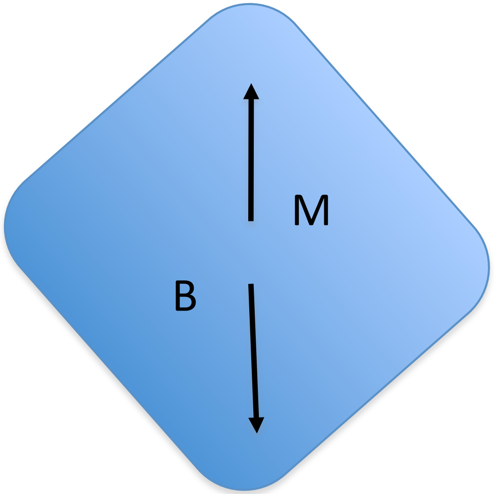
- Archimedes (3 B.C.) discovered upward force was equal to weight of water an object displaced (buoyant force)



Rotation

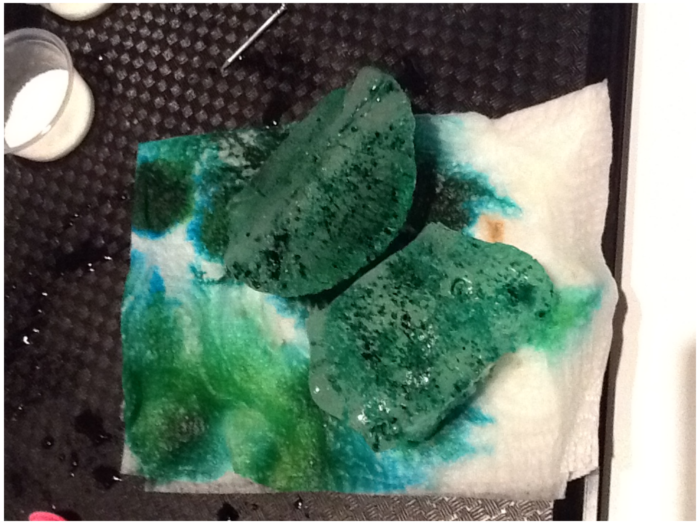
- Objects rotate around their center of mass and the buoyant force acts upward through this point. Floating objects will rotate until two points are aligned

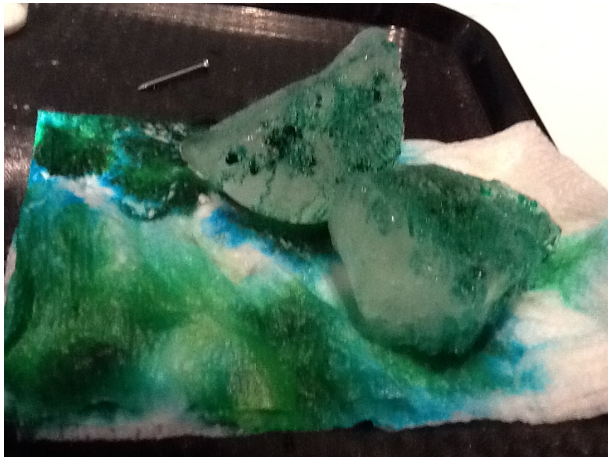




I noticed….I wonder…….

- The salt disassociates into Na^+ and Cl^- ions. The chloride is what changes the green food coloring to blue.
- Ratio of distance solvent moves compared to solute (food coloring) is called Rf value. (yellow dye = 0.5, green dye = 0.8)
- Saltwater pools use electrolysis to break down NaCl and produce hypochlorous acid and chlorine. So you do not add chlorine to the pool, it is already present.



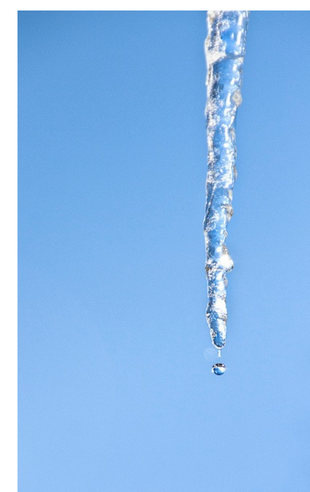


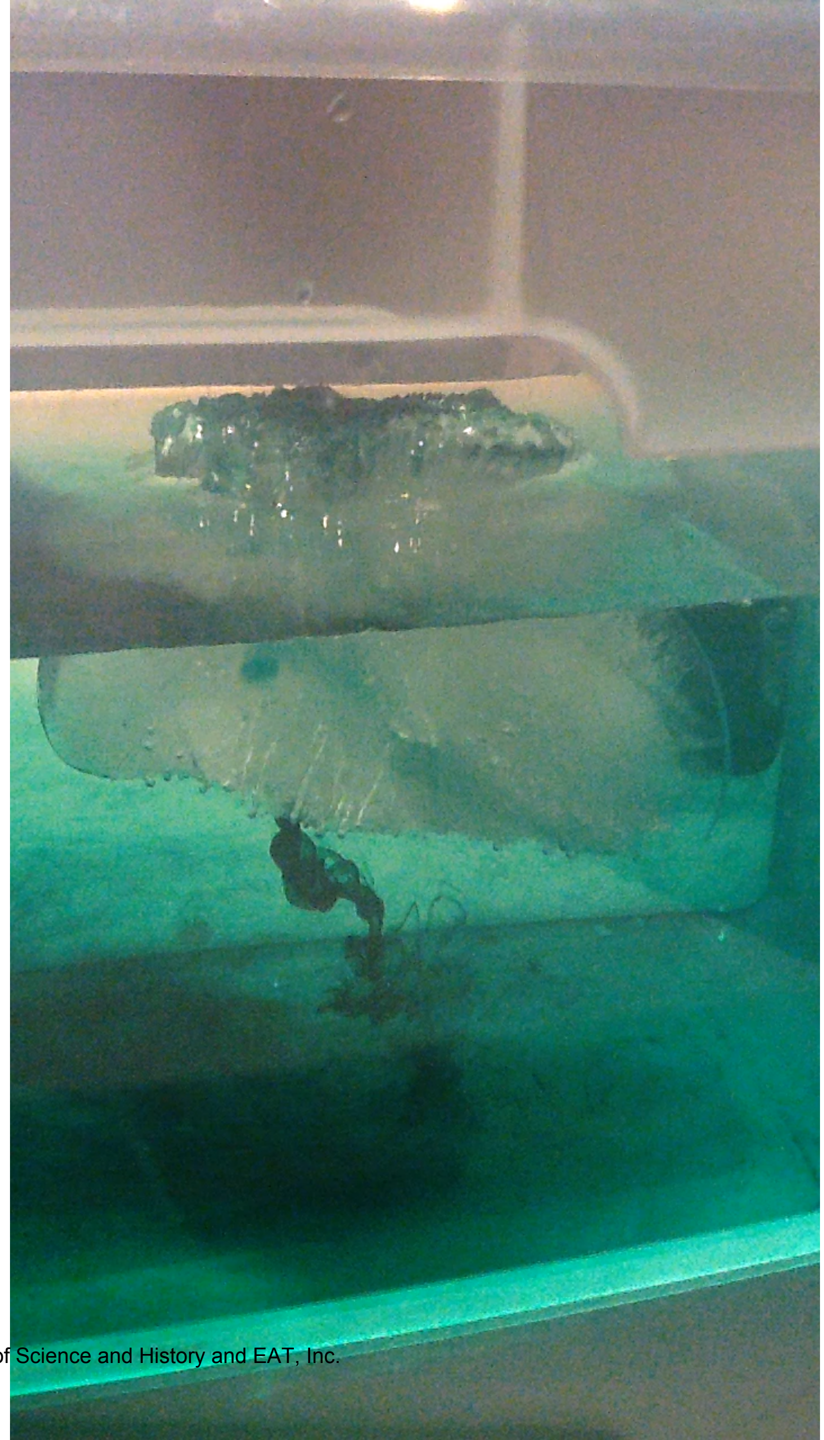
- Ice won't form unless there is a "seed" for the crystal. In absence of a seed, water must be supercooled before crystal structure spontaneously occurs.
- Calcium chloride is often used to melt ice (instead of salt) because it releases heat when dissolved in water.
- Icicles freeze at the tip of a thin tube filled with water
- Suspension of ice crystals in water is "frazil" and most often arrives in form of snow, so snow increases ice formation
- Ice Core Investigations (Science Teacher, Sept 2008)

FIGURE 1

Sample ice core.

This photo shows the variations in layer size and abundance of particulates found in ice core samples.





What is something that you learned about questions?

How can you help your students become more effective questioners?

Making ice balloons

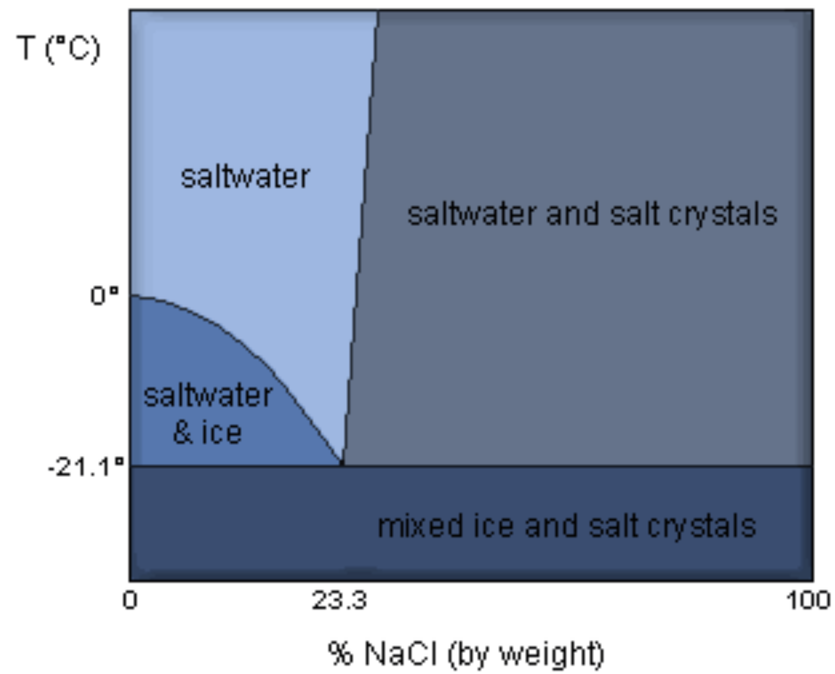
Shape of container
Temperature of water
Type of water
Placement in freezer
Time in freezer

Colligative Properties

- Important to note it is the **amount** of material that is dissolved that influences boiling and freezing points, not type of material.
- Entropy effect
- Generically when you dissolve one substance (solute) in another (solvent) you will raise the boiling point and lower the freezing point.
- Degree of change depends on amount of solute dissolved, not type of solute
- Dissolving salt in water lowers overall vapor pressure so it has to be heated more than pure liquid to vaporize. Number of solvent molecules at the surface of solution is less than for pure solvent affecting the rate of exchange. The resulting reduced vapor pressure of the solvent means a higher temperature is necessary to boil the water in solution (i.e., boiling-point elevation).
- Reducing air pressure can lower boiling point

Freezing Point Depression

As ice freezes out of salt water, water in solution is lowered and freezing point drops further. Eventually solution is saturated. Lowest temp for liquid salt solution is -21.1°C when it begins to crystallize and completely freezes into NaCl*$2H_20$ crystals and ice crystals. The heterogeneous mixture is called eutectic.



http://antoine.frostburg.edu/chem/senese/101/solutions/faq/why-salt-melts-ice.shtml