Science-1A Lab: Week 10, Wednesday, March 17, 2021

The following are somewhat disconnected notes about some chemistry topics.

Bonding in Water

The bonding of oxygen and two hydrogens to make a water molecule is a mix of ionic and covalent bonding with the oxygen being particularly greedy. As a result, the shared electrons spend most of their time around the oxygen giving it a negative charge while the hydrogens tend to be left with positive charges. Because of the "Mickey Mouse" shape of the water molecule, there is a separation between positive and negative charges forming what is called an **electric dipole moment**. Water's dipole moment is very strong and acts like a wrench that can pull apart salt crystals that are placed in water. The salt crystals are said to **dissolve** in water to become free sodium and chloride ions. As more salt is added to the water, however, this process reaches a limit. Some dissolved sodium and chloride ions begin reforming into new crystals as fast as water is taking others apart. This limiting equilibrium concentration of dissolved sodium and chloride ions is called the **solubility** of NaCl in water and is usually expressed as grams per liter (g/L). The solubility of NaCl in water is 360 g/L.

Growing Crystals

You may not have the necessary equipment and conditions to do this right. **So I am just asking you to imagine each step described in the following note.**

A handout about growing salt and sugar crystals is at
https://yosemitefoothills.com/Science-1A/Handouts/Week-10/GrowingNaClCrystals.pdf .

It takes some patience to make a saturated salt solution and then let it grow large 10-mm crystals. Rapid evaporation of the water will lead to numerous small crystals, but no large ones. It also leads to irregular growth that can be pretty, but does not show that natural cubic shape of salt crystals.

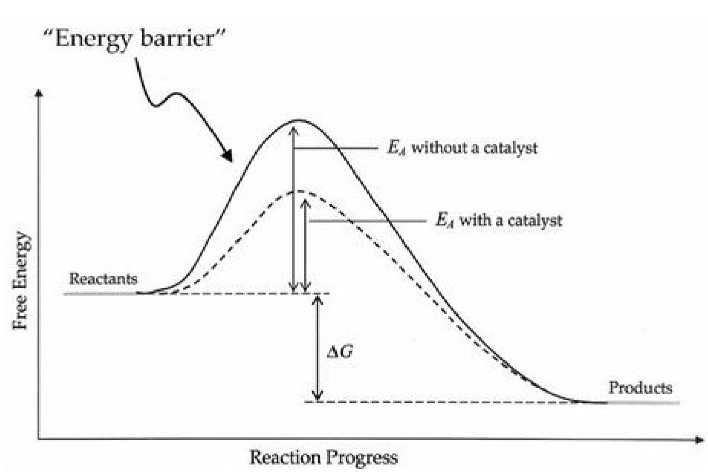
The container must not be sealed closed since slow evaporation of the water is needed, but you also don't want dust falling into it. So some kind of crinkled aluminum foil cover might work.

Ideally, you start with a saturated solution that has no crystals, wait a few days, see some small crystals, prune away all but the largest few, wait longer and repeat. Often more small crystals will appear as you are trying to encourage the growth of your large one. Those should be removed. Adding water can dissolve the small ones, but may also quickly dissolve the large crystal you are nurturing.

If you forget about it for a while, saturated solution will flow up the inside walls of your container and evaporate leaving a salt crust. It may be best to temporarily remove your largest crystal, filter your solution to remove small crystals, and then put your large crystal back. The largest I have grown is about 12 mm square by 3 mm high.

Reaction Energy Barrier

To better understand chemical and nuclear reactions, imagine a car parked at a house above a long downhill driveway, but with a ridge between it and the downhill. The car will not roll out of the driveway because of the ridge, but if it is pushed over the top of the ridge, it will then accelerate down the hill.



The drawing at the right illustrates this same fact as applied to chemical reactions. The reactants are at the left of the hump and cannot become the lower-energy products at the right without help from high temperatures like a spark. At normal temperatures the reactants bump into each other, but cannot get close enough to each other to react; they are repelled by the **energy barrier**. Biological reactions require help to proceed at safe body temperatures. That help is provided by specialized chemicals called **enzymes** that can hold the reactants in a manner that lowers the energy barrier to the point where a particular reaction can proceed at body temperatures.

In general, chemicals that assist chemical reactions are called **catalysts**. Enzymes are useful catalysts used by living organisms. A catalyst is not used up, but having done its job with one reaction, can be reused again and again for more reactions.

As a result catalysts are both powerful and dangerous. Toxins like snake venom are catalysts that interfere with our body's natural catalytic reactions. Pharmaceuticals, often derived from toxins, are catalysts that solve particular medical problems, but often interfere with other reactions producing undesired side effects.

Toxicity of Mercury

Heavy metals like mercury, lead, and cadmium can be toxic if incorporated into certain enzymes in place of the needed metals like zinc and copper. Pure metals are not a problem, but their oxide dust or organic compounds (those with carbon) of those metals are a hazard. See the note on mercury poisoning on the first page of the handout at
https://yosemitefoothills.com/Science-1A/Handouts/Week-09/MercuryToxicity-CarrotsAndVision.pdf .

Carrots and Vision

Here is the interesting story behind the "eat your carrots" mantra we hear. It is on the second page of the note at
https://yosemitefoothills.com/Science-1A/Handouts/Week-09/MercuryToxicity-CarrotsAndVision.pdf .

To get credit for this lab do the following and let me know you have done so:

1. Read the "Growing NaCl Salt Crystals" note.
2. Understand the "Reaction Energy Barrier" idea about how chemical reactions usually need some triggering energy. That also explains why chemical reactions are greatly slowed down at low temperatures making frozen food safer.
3. Read the Toxicity of Mercury note.
4. Read the Carrots and Vision note.