Detailed Instructions | Learning about Solubility

1. Ask them to not touch anything on the table until they are instructed to do so
2. Introduce yourself:
    a. Name
    b. If you are an engineer, type of engineer and background
    c. How you are related to EPIC
3. Explain to the group that you will learning about solubility today. Ask if anyone knows what it means to be soluble?
    a. Define soluble: capable of being dissolved by a solvent. When introduced to a solvent, breaks apart and mixes with solvent to become one solution that maintains a state of being suspended in each other.
    b. Key concepts:
        i. Water is called the "universal solvent" because it dissolves more substances than any other liquid
        ii. What are some things they can think of that might dissolve in water?
            1. Take suggests from the group. Good examples are: sugar, salt, cornstarch and coffee. Things that do not dissolve in water are: pepper and sand
4. Ask them to look at the objects in front of them. Explain that they have a corn starch packing peanut (yellow bigger one), a Styrofoam ball, and a plastic packing peanut.
    a. Ask them which of those objects they thing would be water soluble?
        i. Take a few suggestions, but don't confirm or deny.
        ii. Tell them "let's find out."
5. Have them put on the safety glasses, and hand out gloves from your gloves box to put on. Explain what PPE is and why we use it
    a. PPE = personal protective equipment
    b. We use it to protect ourselves while doing experiments. Scientists, engineers and people who work in manufacturing plants also use PPE for the same reason.
6. Tell them the bowls on the table have water in them. Say that they can take the three objects they have, and put them in the bowls to see what happens.
    a. Give them a few minutes to mess around with the objects in the bowls.
7. Ask them to sit down again. Then ask what they observed.
    a. They should tell you that the packing peanut made of starch got slimy or fell apart
    b. The other two objects will be wet, but should not have undergone a significant change.
    c. Ask them why they think the starch peanut changed and the other didn't
        i. Answer: starch is water soluble but plastic and Styrofoam balls are not
    d. Explain how some substances are not soluble. Give the example of water and oil. Shake up the water and oil jar, and show how they can be mixed, but they still separate again.
    e. Soluble means that something stays mixed together forever and will not separate again.
    f. Pass around the oil and vinegar jar and tell them to look and see how the two substances are trying to separate back out into layers.
    g. Once jar has been seen by everyone, take it back and put it at the front of the room
8. Now explain that are weaker and stronger solvents. Some objects need a stronger solvent to dissolve.

a. Pull out a jug of acetone. Explain what acetone is:
    i. Acetone is the organic compound with the formula $(CH_3)_2CO$.[12] It is a colorless, volatile, flammable liquid, and is the simplest ketone.
    ii. It is a strong solvent, much stronger than water, and used is often used to clean surfaces in homes, laboratories and in manufacturing
    iii. It is also something our bodies produce and is a substance found in blood and urine (pee)
    iv. Common uses are as a paint thinner and nail polish remover

9. Ask them if they think the Styrofoam ball and the plastic packing peanut are not soluble, like water and vinegar? Or will they dissolve in a stronger solvent, like acetone?
    a. Take some predictions from the crowd
    b. Do not confirm or deny, but say "let's find out"
10. Make sure they have safety glasses and gloves on. Wearing your own PPE, pour acetone into your bowl at the front of the room. Drop the Styrofoam ball in, and use the wooden stick to roll the ball around. It should melt.
    a. Take predictions for the peanut that's left. Repeat step 11 for the peanut, and it should also dissolve
11. Now tell them it's their turn to try. One at a time, have each table come up and drop their Styrofoam ball and packing peanut into the bowl and watch them dissolve (they can drop them in at the same time). Give them wooden sticks to stir with.
12. When everyone is done, have them sit back down. Ask them what they observed.
    a. Why do they think the objects melted?
    b. Did they hear or smell anything odd during the process?
        i. They should have heard some popping and smelled the acetone
        ii. Acetone is volatile and is evaporating into the air as it sits in liquid form, giving off the strong smell
        iii. The popping noise is air that is trapped in the structure of Styrofoam being released as it dissolves into the acetone.
        iv. Explain how Styrofoam is designed with air pockets trapped between the molecules, to help give it the squishy, cushy feeling
13. Ask the group if they think that what just happened was a chemical reaction? (Raise hands if you think it was? Raise hands if you think it wasn't?)
    a. Explain that there are three tell-tale signs of a chemical reaction: bubbles, noise, and heat
    b. Ask if they observed any of those things during this experiment
        i. They may have observed noise and bubbles
        ii. The noise is caused by air being released as the foam breaks apart
    c. But this was not a chemical reaction. A chemical reaction requires one substances to change form. But in this case the molecules did not change, they just mixed together. Objects went from solid to liquid, but that is not a reaction, just a state change.
14. Pull out some of the plastic goop in the acetone bowl. Explain that ask long as the solvent is present, the plastic material will remain in a semi-liquid state, kind of like playdoh. But if the solvent evaporates, the plastic will harden into a solid again.
    a. Pass the gloop around after semi-drying it on towel so it doesn't drip. Tell them to hold it away from their bodies, (so they don't get green food dye on themselves).
    b. Once everyone has had a chance to see it, take it back at the front of the room.
15. Explain that chemical and process engineers have to know a lot about solvents, reactions and how substances behave when introduced to each other.

a. Define what a chemical engineer does: the branch of engineering concerned with the design and operation of industrial chemical plants.
b. Explain what a process engineer does: focuses on the design, operation, control, and optimization of chemical, physical, and biological processes
c. One type of system a chemical or process engineer may work on is called a solvent recovery system. This system tries to re-separate the solvent (like water or acetone) from the substance that it dissolved (like the Styrofoam) so it can be recycled.
d. Another area a process engineer might be involved in, is designing a cleaner. Acetone is a cleaner, and many solvents are used in household cleaning chemicals, because they help break down other substances that water and soap cannot remove easily.