RET lesson plan

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Objectives -

Disciplinary Core Ideas (DCI)
HS-PS1-3: Plan and conduct an investigation to gather evidence to compare the structure of substances at the bulk scale to infer the strength of electrical forces between particles.
-[Clarification Statement: Emphasis is on understanding the strengths of forces between particles, not on naming specific intermolecular forces (such as dipole-dipole). Examples of particles could include ions, atoms, molecules, and networked materials (such as graphite). Examples of bulk properties of substances could include the melting point and boiling point, vapor pressure, and surface tension.]

PS1.A: Structure and Properties of Matter
-Attraction and repulsion between electric charges at the atomic scale explain the structure, properties, and transformations of matter, as well as the contact forces between material objects. (secondary to HS-PS11),(secondary to HS-PS1-3)

ETS1.C: Optimizing the Design Solution
-Criteria may need to be broken down into simpler ones that can be approached systematically, and decisions about the priority of certain criteria over others (tradeoffs) may be needed. (secondary to HS-PS1-6)

Science and Engineering Practice (SEP)
Developing and Using Models
-Develop a complex model that allows for manipulation and testing of a proposed process or system.
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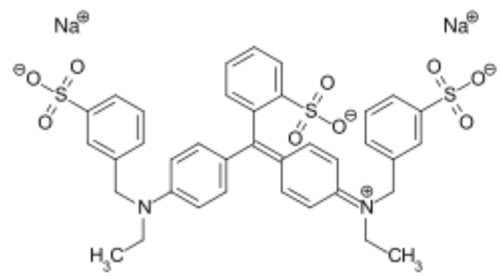
Crosscutting Concepts (CCC)
Scale, Proportion, and Quantity – In considering phenomena, it is critical to recognize what is relevant at different size, time, and energy scales, and to recognize proportional relationships between different quantities as scales change.

-The significance of a phenomenon is dependent on the scale, proportion, and quantity at which it occurs.
-Some systems can only be studied indirectly as they are too small, too large, too fast, or too slow to observe directly

Lesson introduction:

Teacher demo:

The teacher will mix water with blue food coloring and ask the students to create three particle pictures representing the system “before”, “during”, and “after” the process. The teacher will ask several students to “share out” their pictures. The teacher should direct students to create pictures that represent the water and the blue food coloring at the particle level. IDEAL OUTCOME: The class will identify the blue food coloring as a homogeneous mixture. The idea that the water and the blue food coloring have an attraction to one another on the particle level will almost certainly need to be coaxed out of the students via Socratic questioning. This can be adapted to the AP/Organic level by providing the student with the chemical structure of blue food coloring (Brilliant blue FCF*). For the more advanced students the presence of charged atoms and hydrogen bonding sites should be a dead giveaway that this compound is water soluble.



* Wikipedia

Once all relevant concepts (depending on level) have been discussed, the teacher will then mix the blue water and hexane (lighter fluid) IN A CONTAINER WITH A CAP (leave a little air in the container to aid in mixing the two liquids). The teacher will shake/agitate the mixture and then set it down. The student will observe that the two fluids mix initially but upon resting, the blue water settles to the bottom and the clear hexane rises to the top. Once again, the students will create a before, during, and after set of pictures. Allow more time for these pictures and emphasize that pictures should be at the PARTICLE LEVEL. IDEAL OUTCOME: The class will deduce that there is little to no attraction between hexane particles and water particles. Additionally, the student should deduce that there is little to no attraction between the blue food coloring and the hexane particles. Hence the hexane remains clear.

Phet simulation: The students will next be directed to “play with” the Phet simulation below:
https://phet.colorado.edu/sims/cheerpj/sugar-and-salt-solutions/latest/sugar-and-salt-solutions.html?simulation=sugar-and-salt-solutions

The students should select the water tab and observe what happens at the particle level when salt and sugar are mixed with water. [At this point the teacher can hand out a worksheet that has several questions. The students will complete the worksheet] From the worksheet the students will deduce that water dissolves salt and sugar because the water molecules have regions of partial positive and partial negative. Because opposites attract, water should be very effective at dissolving charged particles, ions, and other molecules that have regions of partial positive and partial negative. IDEALLY the student will also deduce that hexane must not have an affinity for water because, unlike water, it has no regions of positive or negative charge (partial or otherwise). The student should be able to categorize particles as being 1) charged (ions) 2) polar (molecules with regions of partial positive/negative) 3) nonpolar (uncharged throughout)

Finally, the teacher will ask the students several questions about the simple phet simulation. We will discuss some of the limitations of the phet model (2-dimensional, sugar molecules are just blobs, etc.). The class will list all the ways that the phet model is deficient/makes approximations and the teacher will write that on the board. Then the teacher will tell the class that simulating the hexane and water demonstration is beyond the capabilities of the phet simulation. The teacher will next show the class the RET simulation video. The students will then list how the RET simulation differs from the phet simulation. The teacher will then list all the ways that the RET simulation differs from the phet simulation on the board.

The final stage of the lesson will consider simulations in general. Each student will answer the question, 1) "Did the simulation show the separation of hexane and water?" 2) "The RET simulation is not perfect. How does the simulation fail to represent reality?" The teacher will then reveal that the RET simulation only shows about 50 nanoseconds and it took 8 hours of computation time. Then the students will answer the question, "Which simulation is better, the phet simulation or the RET simulation?" Ideally, several students will the say, "It depends". Finally, the students will work in groups and list (on whiteboards) several ways the phet is better than the RET simulation and vice versa. These whiteboards will then be held up for all the other groups to see. The should lead to a class discussion that will conclude the lesson.