Lesson # __1__: Vanishing Volume; Phase Equilibrium

Regents Chemistry Unit: Chemical Reactions - Equilibrium

Previous Lesson: Students should have a general knowledge of phase changes, intermolecular forces, particle

Lesson Question	Phenomena	Scientific Practices	What we figure out? Cross cutting concepts & Disciplinary core ideas
Why does water vanish from one beaker and not the other?	The rate of evaporation and the rate of condensation are equal in the closed container.	Developing and using Models	**HS-PSI-6**: ***Refine the design of a chemical system by specifying a change in conditions that would produce increased amounts of products at equilibrium.*** [Clarification Statement: Emphasis is on the application of Le Chatelier's Principle and on refining designs of chemical reaction systems, including descriptions of the connection between changes made at the macroscopic level and what happens at the molecular level. Examples of designs could include different ways to increase product formation including adding reactants or removing products.] [Assessment Boundary: Assessment is limited to specifying the change in only one variable at a time. Assessment does not include calculating equilibrium constants and concentrations.] **DCI – PS1.b**: In many situations, a dynamic and condition dependent balance between a reaction and the reverse reaction determines the numbers of all types of particles present. **CCC** – Stability and change: Much of science deals with constructing explanations of how things change and how the remain stable
Activity Evidence		Students will draw particulate diagrams to model what is happening within the two containers.	Students explore phase change equilibrium. Students observe two containers, one open and one closed system. Students observe that the open container has lost water volume while in the closed system the volume remains constant.

Lesson Materials

1. White boards
2. Handout “Vanishing Volume”
3. 2 graduated cylinders
4. Water & Food Coloring
5. Dry erase markers multiple colors
6. Exit Tickets

Safety

Lesson Breakdown: Why does water vanish from the open beaker but not the closed beaker? Time Frame: 40 minutes or 1 class period)	Teacher Notes
ENGAGE 1. (5 minutes) Show students two graduated cylinders one closed and one open filled with (500 ml) of water. Let it sit. Ask students why water from one graduated cylinder vanished? **Suggested Prompts:** ➢ Revisit drawing particle diagrams – compare solid liquid and gas. Draw a particle diagram of water. **EXPLORE** 2. (2 minutes) Have the students individually draw a model at the molecular level using symbols of what they think happened over the week in the 2 graduated cylinders. 3. (3 minutes) Have students get into groups of 3 to 4 and compare their models to devise 1 group model. **Suggested Prompts:** ➢ Is there only 1 molecule of water present in the graduated cylinder? ➢ Are the water molecules moving, how would you show this in your diagram. ➢ How would you show this in your model? ➢ Are they arranged close together or far apart?	Have students record initial water volume a week before and compare to the volume seen on lesson day. Color the solutions and start with equal amounts. Assign spokesperson and recorder for the groups.

4. (10 minutes) Have 1 student remain the selected model while the other students walk around looking at other group models. One of the group members record observations. **EXPLAIN** 5. (5 minutes) Return students to the their groups to amend their model based on the gallery walk. **ELABORATE** 6. (10 minutes) Have students display amended model in front of class. Begin to create class model. Students should also record the model. **Suggested Prompts:** ➢ Identify the similarities of all the models. Have a student explain why the similarities are good for our class model. ➢ Identify the differences in the models. Have the spokesperson defend their models and the class decides if it belongs in the model. **EVALUATE** 7. (5 minutes) Closing discussion and exit ticket. ➢ If there were 100 molecules in the open cylinders, how many do you think evaporated over the week? ➢ How many do you think evaporated from the closed cylinders? ➢ What causes water to evaporate? Were either beakers in different conditions to evaporate more or less molecules ➢ Why are there water droplets near the top of the closed beaker?	Ask a student to draw the class model on the class white board. Make sure water near top of closed cylinder. Drive home that both cylinders evaporated the same amount because the temperatures is the same, however, the closed cylinder condenses as well. Exit ticket relates population of people to quantity of water.

Lesson # __2__: It's the Last Straw; Equilibrium Simulation

Regents Chemistry Unit: Chemical Reactions - Equilibrium

Previous Lesson: Student discovered in lesson #1 that in a closed system the rate of evaporation is equal to the

This Lesson: Lesson Question	Phenomena	Scientific Practices	What we figure out?, Cross cutting concepts, Disciplinary core ideas
Does the initial concentration of products and reactants affect equilibrium?	Starting with different amounts of reactant and product results in equilibrium.	Developing and using Models Planning and carrying out investigations Constructing Explanations and Designing Solutions	**HS-PSI-6**: ***Refine the design of a chemical system by specifying a change in conditions that would produce increased amounts of products at equilibrium.*** [Clarification Statement: Emphasis is on the application of Le Chatelier's Principle and on refining designs of chemical reaction systems, including descriptions of the connection between changes made at the macroscopic level and what happens at the molecular level. Examples of designs could include different ways to increase product formation including adding reactants or removing products.] [Assessment Boundary: Assessment is limited to specifying the change in only one variable at a time. Assessment does not include calculating equilibrium constants and concentrations.] **DCI – PS1.b**: In many situations, a dynamic and condition dependent balance between a reaction and the reverse reaction determines the numbers of all types of particles present. **CCC** – Stability and change: Much of science deals with constructing explanations of how things change and how the remain stable
Activity Evidence		Students will use a simulation to model chemical equilibrium. Students will investigate using straws to measure a volume and transfer this volume from one container to another. Students will graph the number of transfers versus volume.	Students will explore the concept of chemical equilibrium through a simulation. Students will test when equilibrium is establish by transferring a straws volume of water from a container containing 25 ml of water to another container with 0 ml of water. Students will define the 2 important characteristics of dynamic equilibrium.

Lesson Materials

25 mL graduated cylinder labeled “A”
25 mL graduated cylinder labeled “B”
Drinking straw labeled “A”
Drinking straw labeled “B”
Lab Activity Handout – “What’s Equal About Equilibrium?”

Safety

Lesson Breakdown: It’s the Last Straw; Equilibrium Simulation **Time Frame: 40 minutes**	**Teacher Notes**
ENGAGE 1. (5 minutes) Show video of endless swimming pool. Why isn’t he moving forward? **Suggested Prompts:** ➢ Why isn’t he moving forward? **EXPLORE** 2. (20-30 minutes) Assign specific experiments such as how much water in each container to start with, size of straw, etc. Put students in lab groups of three and have them perform the equilibrium simulation experiment. 3. Students will record data and create graphs of water volume vs. number transfers. **EXPLAIN** 4. (5 minutes) Compare graphs with other groups and answer questions at the end of the lab handout. **ELABORATE**	Initially the rate of water is faster than the rate the swimmer is swimming. The swimmer has to increase the rate to catch up to the rate of the water. Then the swimmers placement remains the same as he reaches dynamic equilibrium with the rate of the water. Each group should be slightly different. Amend as necessary: Group 1: 10mL in A, 0mL in B same straw Group 2: 0mL in A, 10mL in B same straw Group 3: 5mL in each, different size straws. Group 4: 10mL in A, O in B, competing size

5. (3 minutes) Discuss as a class what the graph of the endless swimming pool may look like if we graphed time versus distance traveled by swimmer. Sketch the graph. **EVALUATE** 6. Hand in lab summary/handouts and grade. **Suggested Prompts:** ➢ How did you know you were heading towards dynamic equilibrium? ➢ Why don't the volumes need to be equal at equilibrium?	straw Group 5: 0mL in A, 10 mL in B competing straws. Reinforce that both partners are moving the water (or air) at the same time. Don't drop the straw to ensure hand placement and straw depth in water remains the same. Use the third member as a recorder. Cylinders were used for better measurement accuracy.

Lesson # __3__: Le Chatelier's

Regents Chemistry Unit: Chemical Reactions - Equilibrium

Previous Lesson: Student discovered in lesson #1 that in a closed system the rate of evaporation is equal to the rate condensation. In lesson #2 students investigated and modeled that equilibrium will be established starting

This Lesson: Lesson Question	Phenomena	Scientific Practices	What we figure out?, Cross cutting concepts, Disciplinary core ideas
How does a change in temperature affect a reversible reaction at equilibrium?	Equilibrium gas tubes. The gas changes color to indicate a shift in equilibrium. Two identical equilibrium tubes containing both reddish-brown $NO_{2\ (g)}$ and colorless $N_2O_{4\ (g)}$ are placed in two different temperature (cold and hot) water baths. A third equilibrium tube is left out at room temperature.	Developing and using Models	**HS-PSI-6**: ***Refine the design of a chemical system by specifying a change in conditions that would produce increased amounts of products at equilibrium.*** [Clarification Statement: Emphasis is on the application of Le Chatelier's Principle and on refining designs of chemical reaction systems, including descriptions of the connection between changes made at the macroscopic level and what happens at the molecular level. Examples of designs could include different ways to increase product formation including adding reactants or removing products.] [Assessment Boundary: Assessment is limited to specifying the change in only one variable at a time. Assessment does not include calculating equilibrium constants and concentrations.] **DCI – PS1.b**: In many situations, a dynamic and condition dependent balance between a reaction and the reverse reaction determines the numbers of all types of particles present. **CCC** – Stability and change: Much of science deals with constructing explanations of how things change and how the remain stable CCC – Stability and change, Looking for patterns
Activity Evidence		Students will observe an equilibrium shift by submerging the gas tubes into different water temperatures.	Students will observe LeChatelier's Principle of adding stresses to a system at chemical equilibrium. The students will explore heat as the stress on gas tubes. When heat is added to the tube the reverse reaction rate increases and the color changes to a reddish-brown gas. When heat is removed the forward (exothermic) reaction is favored and the gas will become colorless.

Lesson Materials

1. Equilibrium Tubes
2. Hot water – hot plate
3. Cold Water – ice
4. Room Temperature Water
5. Equilibrium Tube Handout
6. Exit Ticket

Safety

Lesson Breakdown: **Time Frame: 40**	**Teacher Notes**
ENGAGE: (5 min) 1. Give the students the reaction with corresponding colors. 2. Students should complete the Pre-Demonstration Questions 3. Based on the equation make a prediction as to what you will observe. ***(PREDICT)*** **EXPLORE** (5 min) 1. Put gas tube in hot water 2. Make observations. ***(OBSERVE)*** • Put gas tube into room temp water. • Put gas tube in cold water • Students record their observations in the chart on handout **EXPLAIN** (10 min) 3. Students should answer questions 1-3 (THINK) 4. Pair students up to discuss and compare their answers (PAIR) **Suggested Prompts:** ➢ What would have to happen to the rate of the forward reaction if you are seeing a colorless gas? ➢ What would have to happen to the rate of the reverse reaction if you are seeing a reddish-brown gas? **ELBORATE** (10 min)	Two identical equilibrium tubes containing both reddish-brown NO_2 $_{(g)}$ and colorless N_2O_4 $_{(g)}$ are placed in two different temperature (cold and hot) water baths. A third equilibrium tube is left out at room temperature. $2NO_{2\,(g)} \Leftrightarrow N_2O_{4\,(g)}$ + heat reddish-brown colorless The gas tube in warm water turns reddish-brown (favors the reverse reaction/endothermic reaction) The gas tube in cold water turns colorless (favors the forward reaction/exothermic reaction) Link to animation if you don't have gas tubes.

5. Class discussion (SHARE) 6. Students can share the explanations they determined with their partner. **EVALUATE** (5 min) 7. Exit Ticket – Students are to read about the Haber-Basch Process and write the chemical equilibrium equation. Students will explain which way the reaction shifts when heat is added and why.	Learners TV animation of the gas tubes. http://www.learnerstv.com/animation/animation.php?ani=120&cat=chemistry