Aquarium Analogy with Two Aquaria

Models and Simulations

Introduction

Set up two aquaria containing different amounts of water and start bailing, swapping water from one container to another. Will the water levels in both containers keep changing? Will the water levels eventually be the same in both containers? This activity provides a simple and fun way to introduce key concepts relating to reversible reactions and equilibrium.

Concepts

- Reversible reactions
- Equilibrium

Materials (for each demonstration)

Aquaria, large, 2
Plastic cups, 2 each of various sizes
Water
Food coloring
Beaker, 2-L

Safety Precautions

Although the materials used in this activity are considered nonhazardous, please observe all normal classroom and laboratory safety guidelines.

Preparation

Start with two aquaria of equal size. Fill one aquarium with water (add food coloring if desired to make the water level more visible) and leave the second one completely empty.

Procedure

1. Ask for volunteers from the class.
2. The volunteers' task is to transfer the water from one aquarium to the other using the clear plastic cups. Give each volunteer the same size cup to start.
3. The volunteers are given the five rules listed below:
    - The volunteers must pour at exactly the same time.
    - The containers (clear plastic cups) must be as full as possible when the transfers are made.
    - Water cannot be caught during the pouring.
    - The aquaria cannot be tipped.
    - The containers must be used as scoops, not shovels—the water transfers must be done calmly.
4. Ask the members of the class to **predict** what the water level will be in each aquarium when the experiment is completely finished. (The students generally make the same prediction, namely that the levels in the two aquaria will be equal.)

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5. Allow the experiment to proceed without making any additional comments. The students will probably start making a number of comments as soon as the experiment is underway. The students may change their predictions or models based on the observations that they are making.
6. When no further changes are observed in the level of water in the two aquaria, introduce the term *equilibrium* to describe the results.
7. Using the transfer of water from one aquarium (A) to the second (B) as an analogy, ask students to define the term equilibrium for a *reversible reaction* of the type A → B. The definition should include both the properties of the system at equilibrium and how (or why) it is achieved.
8. *(Optional)* Why are the water levels not the same in the two aquaria at equilibrium? Are there any conditions where the water level would be the same in each aquarium at equilibrium?
9. Try the activity with plastic cups that are not the same size.

Tips

- Be very careful in your choice of words when giving the instructions for this exercise. Do not give the idea away before the students have had a chance to experiment with materials and their predictions. If possible use only clear plastic cups or beakers to transfer water from one aquarium to another.

Predict the effect of providing the two volunteers with cups or tranfer containers of different sizes (one about 2 L and the second about 50 mL). Repeat the experiment with the unequal sized containers. Most of the students will predict the equilibrium cannot be established with containers of different sizes. Do the experiment!

- The demonstration can be made into a student experiment with pairs of students using beakers and dropping tubes. The experiment can also be made quantitative by measuring the amount of water transferred each time. Plot the results on a graph of "volume of water transferred" vs "number of pours".
- This activity is useful either as a demonstration or as a cooperative small-group activity to introduce the concepts of reversible chemical reactions and equilibrium.

  The following ideas represent typical student misconceptions about the nature of chemical equilibrium. The concentrations of reactants and products must be equal at equilibrium. *(Having equal amounts of water in the two reservoirs at equilibrium is a special-case scenario that will be observed only if the small containers used to transfer the water are exactly identical.)* Reversible reactions occur in one direction only until all the reactants are depleted, then the reverse reaction begins to take place—think of this as the windshield wiper analogy. *(Both reactions take place simultaneously and reach a state of dynamic equilibrium when the amount of water being removed from each cylinder is the same.)*
- Use the results of this activity to ask leading questions that will help students build more accurate models of chemical equilibrium.
- The "mechanical" analogy between this demonstration and chemical reactions is not perfect. The most obvious place where the analogy breaks down is in the physical separation of reactants and products in separate containers. In reality, of course, there is no "left side" or "right side" in a reversible chemical reaction.

Discussion

This activity demonstrates by physical analogy many important concepts concerning chemical equilibrium. (1) At equilibrium, the rate of the forward reaction equals the rate of the reverse reaction. In the aquarium analogy, this is clearly evident because water continues to be exchanged between the two reservoirs, but the amount being removed is the same as the amount being added to each container. (2) The fact that the amounts of reactants and products remain constant once equilibrium is reached is the net result of a dynamic series of events, not a static condition. In the analogy, students should continue to transfer water for a few cycles even after the water levels no longer change—there is no reason the process cannot continue indefinitely. (3) Equilibrium can be approached from different "directions" (from the reactant or product side). This is easy to demonstrate in the aquarium analogy by having different groups start with water in either aquarium.

Connecting to the National Standards

This laboratory activity relates to the following National Science Education Standards (1996):

Unifying Concepts and Processes: Grades K–12
Systems, order, and organization
Evidence, models, and explanation
Evolution and equilibrium

Content Standards: Grades 9–12
Content Standard A: Science as Inquiry
Content Standard B: Physical Science, structure and properties of matter, chemical reactions
Content Standard G: History and Nature of Science, nature of scientific knowledge

Flinn Scientific—Teaching Chemistry™ eLearning Video Series

A video of the *Aquarium Analogy with Two Aquaria* activity, presented by Irwin Talesnick, is available in *Models and Simulations*, part of the Flinn Scientific—Teaching Chemistry eLearning Video Series.

Materials for *Aquarium Analogy with Two Aquaria* are available from Flinn Scientific, Inc.

Catalog No.	Description
FB0210	Aquarium, All-Glass®, 5 1/2 gal
V0003	Food Coloring, Dye Set
AP1206	Beaker, Polymethylpentene, 50-mL
AP1208	Beaker, Polymethylpentene, 250-mL
AP1210	Beaker, Polymethylpentene, 600-mL

Consult your *Flinn Scientific Catalog/Reference Manual* for current prices.