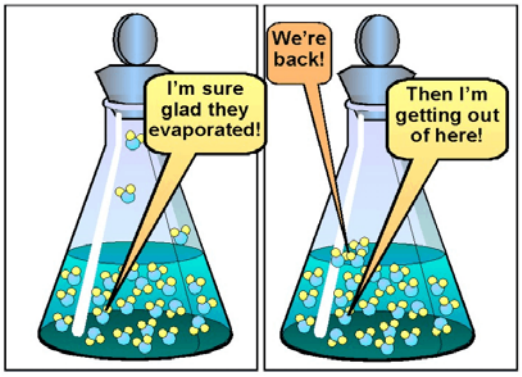
The Ins and Outs of Equilibrium

If you leave a closed, partly filled bottle of water in the sunlight, before long you will observe water droplets near the top of the bottle and in the neck. How did they get there? As the sun shines on the bottle, the water begins to evaporate. As the number of vapor molecules increases, so does the chance that they will interact with each other and recondense to form water. This is how the water droplets get to the top of the bottle.

Changing phase is a reversible process. In a closed container, as the amount of vapor increases and the amount of liquid decreases, the rate of condensation increases and the rate of vaporization decreases. Eventually the two rates become equal. When the rate of vaporization is equal to the rate of condensation, the amount of vapor and the amount of liquid stops changing. This is called **equilibrium**. Just because the rate of vaporization and condensation is equal at equilibrium, it doesn't mean that the amount of vapor and the amount of liquid is equal. For example, the amount of gas at equilibrium will be greater at a high temperature than at a low temperature.



The social dynamics of phase equilibrium

There are other kinds of equilibrium besides phase equilibrium. Some chemical reactions are reversible and reach equilibrium too. When undissolved solid sits at the bottom of a saturated solution, there is solution equilibrium. It may look like the same undissolved solid at the bottom of the container the entire time, but dissolved material comes out of solution and new material dissolves continuously. Only the amount of undissolved material remains the same. This is often called **dynamic equilibrium** because there is constant activity although there is no real change.

Answer the questions below based on the reading above and on your knowledge of chemistry.

1. What is a reversible reaction? _____

2. What is equilibrium? _____

3. The double replacement between silver nitrate solution and sodium chloride solution is written with a single arrow. [$AgNO_3(aq)$ + $NaCl(aq)$ → $NaNO_3(aq)$ + $AgCl(s)$] The double replacement between potassium iodide solution and lithium hydrogen carbonate is written with a double arrow. [$KI(aq)$ +$LiHCO_3(aq)$ ⇌ $KHCO_3(aq)$ + $LiI(aq)$]

   a. What does the double arrow probably mean? _____

   b. What accounts for the difference between the two reactions? _____

   c. Will the reaction $AgNO_3(aq)$ + $NaCl(aq)$ → $NaNO_3(aq)$ + $AgCl(s)$ ever reach equilibrium? Explain. _____

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4. An extremely soluble salt is added to water, and all of it dissolves. Is it at equilibrium? Explain. _____

5. A slightly soluble salt is added to water, and some of it dissolves. Is it at equilibrium? Explain. _____

6. Liquid water and water vapor reach equilibrium only in a closed container. Why? _____

7. Explain equilibrium based on collision theory. _____

8. A glass of ice water is at equilibrium.
   a. What is its temperature? _____
   b. What is happening to the amount of ice in the ice-water mixture? _____
   c. What is happening to the amount of water in the ice-water mixture? _____
   d. How does the amount of ice compare to the amount of water? _____
   e. Describe what is happening in the ice-water mixture if the system is at equilibrium. _____

9. The reaction $H_2O(\ell) + CO_2(aq) \rightleftharpoons H_2CO_3(aq)$ is at equilibrium. What does this mean? _____