

# SCIENCE 1107

## EQUILIBRIUM SYSTEMS

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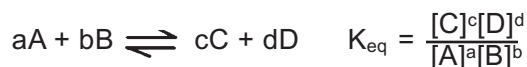
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## II. SOLUBILITY EQUILIBRIUMS

In Science LightUnit 1106 you studied the concept of equilibrium. You learned that an equilibrium condition was a dynamic system in which the rate of reaction in one direction was equal to the rate of reaction in the opposite direction (reactants  $\rightleftharpoons$  products). The building process was equal to the decaying process.

You also found that the mathematical expression for a chemical equilibrium was given by the following expression:



In the next three sections of this LightUnit, you will study specific types of equilibrium systems. In this section you will study systems in which a solid is in equilibrium with its dissolved form. Some practical applications of the concepts of this section will be used to show you the importance of this study. Review Section III of Science LightUnit 1106 for further reference.

### SECTION OBJECTIVES

**Read these objectives.** When you have completed this section, you should be able:

6. To apply the concepts of equilibrium to the dissolved-undissolved system.
7. To apply the *Law of Chemical Equilibrium* to the dissolved-undissolved system.
8. To predict if a precipitate will form given specific environments.
9. To describe the variables affecting the rate of dissolving.

### DISSOLVING AND DISSOCIATING

The formation of a solution occurs in two steps. The first is the separation of the solute into ions or molecules and the second is the diffusion of the solute throughout the solvent. The second step was discussed in depth in a previous LightUnit. If you need to refresh your memory on the kinetics of diffusion, review pages 2 and 3 of Science LightUnit 1103.

**Definition.** Dissolving and dissociating is the mechanical separation of the ions or molecules that make up the solute. Study Figure 2. Notice that when dissolving starts, all of the solute particles move away from the solute source. After a little time, the concentration of the solute particles around the source has increased to a level where some of the solute particles randomly hit the source and reattach themselves to the source.

Still, the net result is more movement away from the solute source than back to the source. The attraction of the solvent for solute particles and the diffusion-dilution process cause the dissolving to proceed away from the solute source until an equilibrium is established.

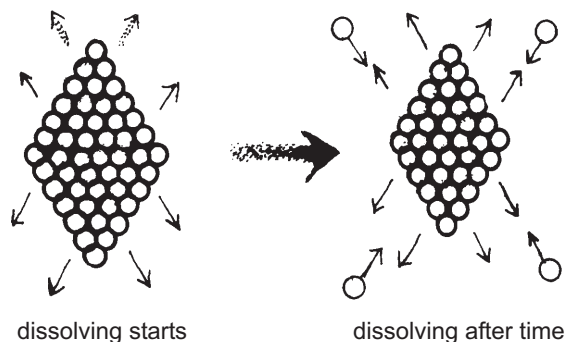


Figure 2



**Complete these statements.**

- 2.1 A solution is formed by the processes of a. \_\_\_\_\_ and b. \_\_\_\_\_.
- 2.2 The substance that is dissolving is called the \_\_\_\_\_.
- 2.3 The process of intermingling of the ions (molecules) of one substance into another is called \_\_\_\_\_.

- 2.4 Dissolving continues until an \_\_\_\_\_ is reached.
- 2.5 The dissolving process is primarily \_\_\_\_\_ the solute when the dissolving begins.

**Factors affecting rate.** A solution is a homogeneous mixture of two or more substances. The composition of a solution may vary within certain limits. Varying amounts of solute may be dissolved and varying amounts of solvent may be used. The solution process and those physical factors that affect it will be studied in the next

investigations.

The factors affecting the rate of dissolving/dissociation will be investigated by the inductive approach. You will explore the factors and from your results develop your ideas and generalizations. The following materials will be used to investigate all four factors.



**Do these investigations.**



**These supplies are needed:**

- |                   |   |
|-------------------|---|
| balance           | 2 baby food jars with lids or small beakers       |
| water             | graduated cylinders                               |
| test tubes        | rock salt (water softener crystals)               |
| glycerine         | rubbing alcohol (isopropyl alcohol)               |
| several teaspoons | test tubes                      mortar and pestle |



**Follow these directions and complete these activities.** Put a check in the box when each step is completed.

**Effect of solvent**

- 1. Place 2 ml of water in a test tube, 2 ml of alcohol in a second test tube, and 2 ml of glycerine in a third test tube.
- 2. Label each to avoid confusion.
- 3. Drop a crystal of NaCl into each test tube.
- 4. Shake each test tube gently for about one minute. Later: To clean the glycerine tube, pour the alcohol and/or water into it to dissolve the glycerine.

- 2.6 What results?
- a. H<sub>2</sub>O = \_\_\_\_\_
- b. alcohol = \_\_\_\_\_
- c. glycerine = \_\_\_\_\_

2.7 In which liquid is the salt most soluble? \_\_\_\_\_

2.8 Using the concept of "Like dissolves like," explain why you got the results you did in 2.6.

\_\_\_\_\_

\_\_\_\_\_

2.9 Explain how the choice of solvent affects the dissolving process. \_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

### Effect of pulverizing

- 5. Weigh out two 2 g portions of coarse crystals. Save them on teaspoons, until needed.
- 6. Grind one portion to a fine powder, but do not pound the crystals. They can be ground between two teaspoons.
- 7. Now add 25 ml of water to each baby food jar.
- 8. Place the coarse crystals into one jar.
- 9. Agitate the jar with a swirling motion. Observe the time required for complete solution.
- 10. Place the finely ground crystals into the other jar. Agitate with a swirling motion. Record the time for the complete solution.

2.10 Record of dissolving times.

a. crystal = \_\_\_\_\_

b. pulverized = \_\_\_\_\_

2.11 Why are the dissolving rates different? \_\_\_\_\_

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### Effect of temperature

- 11. Weigh out two 2 g portions of coarse salt crystals. Save them on teaspoons until needed.
- 12. Measure out 25 ml of ice water into one jar.
- 13. Add one 2 g portion of crystals. Agitate gently. Record the time for dissolving.
- 14. Measure out 25 ml of hot water into the other jar.
- 15. Wrap the hot jar in paper or cloth to keep it hot and to avoid a burn to your hand. You may also wear a glove to avoid burns.
- 16. Add 2 g salt crystals.
- 17. Agitate the jar and record the time required to dissolve the sample.

2.12 Record of dissolving times.

a. cold = \_\_\_\_\_

b. hot = \_\_\_\_\_

2.13 Using the concepts of kinetic energy, describe why you found the results you did in 2.12.

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### Effect of stirring

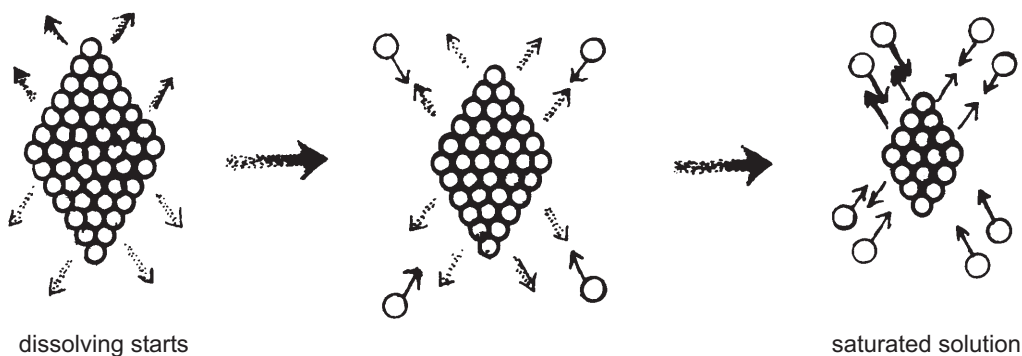
- 18. Weigh out two 2 g portions of coarse salt crystals. Save them on teaspoons until needed.
- 19. Put 25 ml of tap water in each of 2 jars. Let them stand undisturbed for 2 minutes.
- 20. Add a weighed salt sample to each jar.
- 21. Stir one sample and leave the second sample unstirred. Record the times necessary to dissolve each sample.

- 2.14 Record of dissolving time.  
 a. stirred = \_\_\_\_\_  
 b. unstirred = \_\_\_\_\_
- 2.15 Explain the results recorded in 2.14. \_\_\_\_\_  
 \_\_\_\_\_  
 \_\_\_\_\_
- 2.16 Review the four factors of dissolving you have just investigated. Given the correct solvent for a solute, what could you do to hasten the solution process?  
 1. \_\_\_\_\_  
 2. \_\_\_\_\_  
 3. \_\_\_\_\_

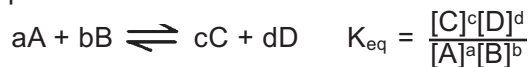


## SOLUBILITY CONSTANTS

When a solution reaches a point where the rate of dissolving equals the rate of reforming (solidification), the system is in equilibrium (dissolved  $\rightleftharpoons$  undissolved). This equilibrium system is the one you will study in this section of your LightUnit.



**K<sub>sp</sub>.** In your study of Science LightUnit 1106, you were introduced to the general concepts involved in equilibrium. The Law of Chemical Equilibrium was described as



You will now learn to apply the equilibrium law to the equilibrium system of a saturated solution in which a solid is in equilibrium with its dissolved form.



### Do these activities.

- 2.17 Our laboratory studies will be based upon the system of  $PbCl_{2(s)} \rightleftharpoons Pb^{2+}_{(aq)} + 2Cl^{-}_{(aq)}$ .
- a. For every  $Pb^{+2}$  ion that is formed, how many  $Cl^{-}$  ions are formed? \_\_\_\_\_
- b. For every mole of  $Pb^{+2}$  ions that are formed, how many  $Cl^{-}$  ions are formed? \_\_\_\_\_