Velcro Gloves and Ball Set

Introduction to Acids and Bases

Introduction

Have some fun with this Velcro gloves and ball set as you reinforce the concepts of Bronsted–Lowry acids and bases and demonstrate the bond energy in hydrogen bonding.

Concepts

- Bronsted–Lowry acids and bases • Hydrogen bonding

Background

Bronsted–Lowry Acids and Bases

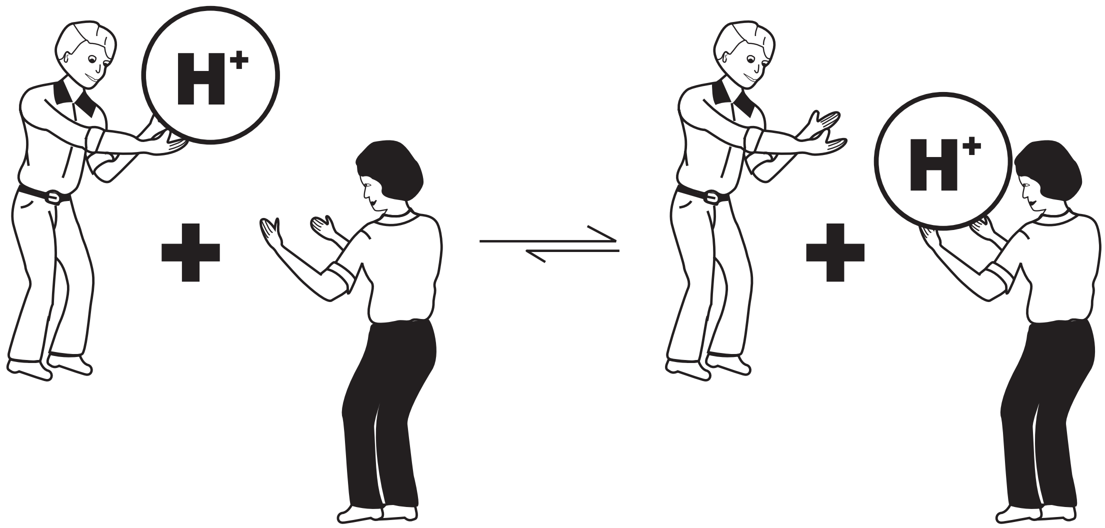
The Bronsted–Lowry (B/L) definition of acids and bases is often not easy to grasp. [As Lee Marek says, "It is kind of hard for a kid to swallow—please don't let them do that!"] It goes back to 1923 when the Dane, Johannes Nicolas Bronsted and Englishman, Thomas Martin Lowry independently developed a new definition of acids and bases. The Bronsted–Lowry theory defines an *acid* as a proton donor and a *base* as a proton acceptor. ["Right away, kids are messed up!" Lee says. "You have to remind them that a proton here really refers to a hydrogen (H) atom that has lost an electron to form H^+. A hydrogen ion is really just a proton, but not in the sense of a proton ripped out of the nucleus. This does mess with students' minds."]

Another concept that confuses students is the idea that when a B/L acid reacts with a B/L base, the reaction yields another acid and another base—a *conjugate acid* and *conjugate base*, with conjugate simply meaning "paired together". The resulting solution is not necessarily neutral as we might think when we mix an acid and a base—it could be acidic or basic, depending on how far the reaction goes to products and on the acidity of the conjugate acid or base.

In the reaction below, HA gives up a proton to a B^- ion. Hence, HA is acting as an acid (proton donor) and B^- is acting as a base (proton acceptor). If we consider the reverse reaction, the HB acts as an acid since it donates a proton to the base A^- that accepts the proton. The equilibrium reaction is represented as follows:

HA	+	B^-	→	HB	+	A^-
acid		*base*		*conjugate acid of* B^-		*conjugate base of HA*
(proton donor)		*(proton acceptor)*				

To decide which side (products or reactants) "wins," the relative strength of the two acids (HA versus HB) or two bases (A^- versus B^-) must be considered. If HA is stronger, then equilibrium will favor the forward reaction and HB will be in abundance, as shown in the diagram below. If HB is stronger, then equilibrium will favor the reverse reaction and HA will be in abundance. The stronger acid (HA) "wins," rids itself of the proton, and dissociates to its conjugate base (A^-), leaving the weaker acid (HB) in abundance. Think of the stronger acid (which by definition prefers to dissociate into its ions and "get rid of" a proton) as tossing the proton onto the base to form the conjugate base and the weaker acid (which by definition prefers to remain in the molecular form and keep its proton). Note that the stronger the acid, the weaker the conjugate base it forms. Thus, in the drawing below, the conjugate base of HA (A^-) is a weaker base than B^-. Hence A^- will not accept, or attract, a proton as readily as B^-.



Stronger acid, HA *Base, B^-* *Conjugate base, A^- (potential acceptor)* *Conjugate acid, HB (potential donor)*

Materials

Velcro gloves, 2

Cloth ball

Safety Precautions

This activity is considered nonhazardous. Please follow all classroom safety guidelines.

Procedure

Part A. Alternative Assessment

1. Explain the Bronstead-Lowry acid-base theory and perform practice problems.
2. Use the Velcro gloves and balls as a "practical exam" for the students.

Part B. Group Activity

1. Invite several students (2, 4 or 6) to the front of the class.
2. Each student will wear one Velcro glove.
3. Instruct students they are either anions or bases.
4. The goal of the activity is to determine which students in the group are the anions (conjugate bases) of the strongest acids.

Part C. Battle of the Strongest Acid

1. Hold all the protons (cloth spheres) in your hands.
2. Inform students you are going to drop the protons on the floor and the strongest acid wins! Tip: To encourage participation offer extra credit or a small prize for the strongest acids in the group.
3. Several students will compete for the protons but they miss the entire concept. In this activity, the meek (who do not grab spheres) do not inherit the proton, and win the prize! The students who grab the cloth spheres are the weak acids while the strong acids give up their protons!

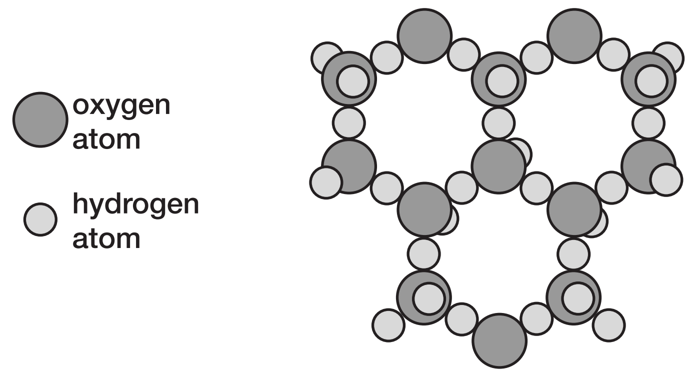
Part D. Velcro Hydrogen Bonding

Note: Several glove sets are needed for this activity; student volunteers should be wearing sweaters so that the Velcro can stick. It is best if students have sweaters that won't snag.

1. Choose student volunteers (six is ideal) who have small hands and are wearing sweaters. Each volunteer should put on two

Velcro gloves, one on each hand, even though all of the gloves are left-handed. *Note:* Students with small hands may have an easier time fitting both hands into the left-handed gloves.

2. The students represent water molecules. Have them hold out their arms at 105° angles to show the bond angles in water. The gloves represent the hydrogen atoms and the sweater represents the oxygen atom with the non-bonding "lone" pairs of electrons.
3. If the Velcro glove (H) comes in contact with the back of someone else's sweater (O), the glove will stick. This represents a hydrogen bond. It is easily broken, however, since it does not take much energy to break the bond.
4. If there are, for instance, six students with gloves, show how bonds form and break all the time, as in a liquid. All six students should be forming and breaking bonds. Use more students if you have additional glove sets.
5. If it gets a little hot, one can escape and enter the gaseous state. Have one student break away and run out of the room (or to a far corner of the room). If they all become gases, have the six move around a little faster and spread out to a volume much bigger, with many meters between each other. Notice bonds cannot be made and broken when they are far apart.
6. Now "cool them off" and have the six students try to arrange themselves in the open hexagonal pattern that ice forms. (See the diagram to the right.) Ice has a lower density than water because of the open spaces. Each oxygen is bonded to four hydrogen atoms—two bonds are covalent bonds within a water molecule and the other two are hydrogen bonds to adjacent water molecules. The open space will become very apparent when your students have formed this pattern. (*Note:* The ice structure is a three-dimensional structure, where the diagram below is depicted in two dimensions.)



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Disposal

The Velcro gloves and ball set may be stored for future use.

Connecting to the National Standards

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

Unifying Concepts and Processes: Grades K–12
Evidence, models, and explanation
Content Standards: Grades 9–12
Content Standard B: Physical Science, structure and properties of matter, chemical reactions.

Acknowledgments

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References

Fortman, John J. "Pictorial Analogies XI: Concentrations and Acidity of Solutions," *J Chem Ed;* **1994,** *71*, 430–432.
Hill, John W. "A People-and-Velcro Model for Hydrogen Bonding," *J Chem Ed;* **1990,** *67*, 223.

Flinn Scientific—Teaching Chemistry™ eLearning Video Series

A video of the *Velcro Gloves and Ball Set* activity, presented by Lee Marek, is available in *Introduction to Acids and Bases*, part of the Flinn Scientific—Teaching Chemistry eLearning Video Series.

Materials for *Velcro Gloves and Ball Set* are available from Flinn Scientific, Inc.

Catalog No.	Description
AP5450	Velcro Gloves and Ball Set

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