Activity: Intermolecular Forces

FOR THE TEACHER

Summary
In this activity, students will represent molecules and energy to investigate the different types of intermolecular forces. They will interact with each other to model the relative strengths of the three types of intermolecular forces.

Resource Type  Grade Level
Activity  High school

Objectives
By the end of this lesson, students should be able to
- Understand the difference between hydrogen bonds, dipole-dipole interactions, and London dispersion forces.
- Recognize that the different types of intermolecular forces require different amounts of energy to overcome these interactions.

Chemistry Topics
This lesson supports students’ understanding of
- Intermolecular forces
- Physical changes

Time
Teacher Preparation: 10 minutes
Lesson: 20 minutes

Materials
- Notecards with molecules written on them (each card has molecules that are examples of when hydrogen bonds, dipole-dipole, or London dispersion interactions occur)
  - H₂O–H₂O, HF–HF
  - PCl₃–CH₃Cl, HBr–HBr
  - Cl₂–Cl₂, CH₄–CH₄
- Two student volunteers per intermolecular force type
- Notecards with energy amounts written on them
  - High energy
  - Medium energy
  - Low energy
- One student (or three) volunteer(s) to represent energy

Safety
Students who participate in the activity will touch and be touched by other students—they will hold and push each other’s hands and shoulders.

Teacher Notes
Answer key for Intermolecular Forces Worksheet
1. London dispersion forces
2. dipole-dipole
3. hydrogen bonds
4. dipole-dipole
5. dipole-dipole
6. hydrogen bonds
7. London dispersion forces
8. London dispersion forces
9. dipole-dipole
10. London dispersion forces

FOR THE STUDENT
Student Activity Sheet: Intermolecular Forces Worksheet

Lesson
Once students have learned about intermolecular forces (hydrogen bonds, dipole-dipole, and London dispersion forces), they can participate in this activity. They represent energy and molecules with the different types of intermolecular forces. Warn students about touching and being touched by other students—they will hold and push each other’s hands and shoulders. Model students how to show the electron clouds (see illustration below). Use your discretion whether to use this activity in your classroom or to modify it based on interaction level among students. Warn students that they are not showing off their physical strength by knocking off other classmates.

How to represent a polar molecule (illustrated):
Students will put their arms out in front of them so their arms are parallel to the floor and their palms should be together in front of their body. The shoulder end of their arms is the partial negative end of the molecule. Their hand end is the partial positive end.

How to represent a nonpolar molecule (no illustration):
Students should stand straight, arms relaxed by the side of their body.
Activity
Have three note cards with the two pairs of molecules clearly written. Also write the pairs of molecules on the board for the class to see:

1. \( \text{H}_2\text{O} – \text{H}_2\text{O}, \text{HF} – \text{HF} \)
2. \( \text{PCl}_3 – \text{CH}_3\text{Cl}, \text{HBr} – \text{HBr} \)
3. \( \text{Cl}_2 – \text{Cl}_2, \text{CH}_4 – \text{CH}_4 \)

One pair of students is needed for each molecule example (six students total), and at least one student is needed to represent energy, or you could have one student per energy amount. Molecule pairs should pick the index card with example molecules that their intermolecular force goes with, and if more than one student is energy, the energy students should pick their energy status card (low, medium, high).

Molecule students will show their index cards (formula is written in large font to read from afar) to demonstrate attractions between each molecule pair.

Energy students will show the low energy index card first. If the attraction is not broken, then show the medium index card. In the event of failing to break the attraction, show the high energy index card to class.

Hydrogen bonds
The two molecule students will show polarity with their arms. They should move randomly until one student’s hands are close to the other student’s shoulders. The students hand should connect to the other student’s shoulders (like they are making a train). The teacher announces that the attraction is formed and to show the strength of the attraction will try to break the attraction by providing energy. The teacher should ask the rest of the class to predict whether a low, medium, or high amount of energy is needed to break the attraction.

The student who represents low energy should try to separate the attractive force by pushing the two students gently (energy student should show the index card to the class first). This will show that low energy cannot separate the molecules. Then the medium energy student will use a little more force to try and disconnect the molecule students. Finally, the high energy volunteer will remove the hands from the shoulders and the molecule volunteers should step away from each other.

The students should conclude, or the teacher should announce, that the attraction was very hard to break.

The energy volunteer will gently touch both of the molecule volunteers (low energy), then push little harder (medium energy), and finally remove the hands from the shoulders (high energy).
**Dipole-dipole**

Both molecule students will show the polarity with their arms. They should move randomly until one of student’s hands touches the other student’s shoulders lightly (doesn’t hold the shoulder tightly). Teacher will announce that the attraction is formed. The teacher announces that the attraction is formed and to show the strength of the attraction will try to break the attraction by providing energy. The teacher should ask the rest of the class to predict whether a low, medium, or high amount of energy is needed to break the attraction.

The student who represents low energy should try to separate the attractive force by pushing the two students gently (energy student should show the index card to the class first). This will show that low energy cannot separate the molecules. Then the medium energy student will use a little more force to try and disconnect the molecule students.

The students conclude, or the teacher should announce, that the attraction was not easy to break, so the attraction is not the weakest.

**London dispersion forces**

Molecule students show the nonpolar molecule by keeping their hands to their side while they move around each other. When they get closer to each other, they become polar and one student moves their hands to the other student’s shoulders. They freeze, and there should be a visible distance between the students. The teacher announces that the attraction is formed and to show the strength of the attraction will try to break the attraction by providing energy. The teacher should ask the rest of the class to predict whether a low, medium, or high amount of energy is needed to break the attraction.

The student who represents low energy should try to separate the attractive force by pushing the two students gently (energy student should show the index card to the class first). The molecule students put their arms down and step away from each other.

The students conclude, or the teacher should announce, that the attraction was easy to break, so the attraction is the weakest.
Now have students practice without modeling the types on interactions by having them complete the **Intermolecular Forces Worksheet**.