Simulation: Intermolecular Forces

FOR THE TEACHER

Summary
In this simulation, students will review the three major types of intermolecular forces – London dispersion forces, dipole-dipole interactions, and hydrogen bonding – through short video clips and accompanying text. They will then answer quiz questions using the relative strengths of these forces to compare different substances given their name, formula, and Lewis structure, and put them in order based on the strength of their intermolecular forces, their boiling point, or their vapor pressure. The simulation is designed as a five question quiz for students to use multiple times.

Grade Level
High School

NGSS Alignment
This simulation will help prepare your students to meet the performance expectations in the following standards:

- **HS-PS1-3**: Plan and conduct an investigation to gather evidence to compare the structure of substances at the bulk scale to infer the strength of electrical forces between particles.

- **Scientific and Engineering Practices**:
  - Developing and Using Models

Objectives
By the end of this simulation, students should be able to:

- Rank intermolecular forces in order of strength.
- Determine the strongest type of intermolecular force experienced by a substance given its Lewis structure.
- Describe the effect of different intermolecular forces on boiling point and vapor pressure.
- List a set of substances in order of strength of intermolecular forces, boiling point, or vapor pressure based on their Lewis structure.

Chemistry Topics
This simulation supports students’ understanding of:

- Intermolecular forces
- Polarity
- Physical properties

Time
**Teacher Preparation**: minimal
**Lesson**: 20-30 minutes

Materials
- Computer, tablet or phone with internet access
- [https://teachchemistry.org/classroom-resources/intermolecular-forces-2020](https://teachchemistry.org/classroom-resources/intermolecular-forces-2020)

Safety
- No specific safety precautions need to be observed for this activity.
Teacher Notes

- The simulation can be found at the following link (note that students can access the simulation without an AACT login):
  - https://teachchemistry.org/classroom-resources/intermolecular-forces-2020
- This simulation could be used during a unit about bonding.
- The quiz randomly presents 5 of the 10 possible questions, so that a student could repeat the quiz and not get the same 5 questions if they are in need of extra practice.
- Since the questions are randomized, students working on the quiz at the same time will not have the same questions in the same order.
- Each question is worth 2 points. For the first three questions, students will choose between two molecules and so will only have one chance to answer the question correctly. For the last two questions, they will be putting three molecules in order, so they will have two chances to do it correctly as there are more possible configurations. If they get it on the second try, they will be awarded 1 point instead of 2. Explanations are provided with the answers for each question.
- There is no student handout associated with this simulation. Students will be given instructions, and answer questions using the simulation interface.

Important Notes:

- The introductory videos and accompanying text will give students a brief summary of the different intermolecular forces, including whether they occur in polar or non-polar molecules and their relative strengths, but it will probably be most beneficial if students have been introduced to the concepts of intermolecular forces, molecular geometry, and molecular polarity prior to using this simulation.
- Be sure that students understand that molecules often have multiple types of intermolecular forces at the same time. For example, all molecules experience London dispersion forces, even if they also have other types of intermolecular forces. If molecules of a substance exhibit dipole-dipole interactions, they also experience London dispersion forces, and if molecules experience hydrogen bonding, they also have dipole-dipole interactions (of which hydrogen bonding is a particularly strong example) and, of course, London dispersion forces. These forces are “stackable,” like Russian nesting dolls. The explanations in the simulation only mention the most relevant of the forces to the particular molecules in question to keep them focused and avoid overly long explanations; they may not mention all of the forces present in each molecule.
- It should be made clear that intermolecular forces will always be weaker than the intramolecular forces (ionic, covalent, or metallic bonding) in a particular substance.
- Be sure to emphasize that “hydrogen bonding” is an intermolecular force, not a bond/an intramolecular force, like ionic, covalent, or metallic bonds.
- This simulation presents London dispersion forces as the weakest intermolecular force, followed by dipole-dipole interactions, with hydrogen bonding being the strongest. This is true when comparing molecules of similar size, but there are ranges for each type of intermolecular force. As noted in the introduction on London dispersion forces, the larger the molecule is, the more electrons it has, which gives it a larger temporary, or instantaneous, dipole and stronger dispersion forces. All of the questions in this simulation, however, use molecules of similar size so they all follow the general rule that London dispersion forces are weakest, followed by dipole-dipole interactions and then hydrogen bonding, to avoid this confusion.
- For some large molecules, the London dispersion forces are actually relatively strong, stronger than dipole-dipole interactions or even hydrogen bonding present between smaller molecules.
  - As an extension for this lesson, you could discuss some examples where the rules are broken. One of these would be comparing water, which has hydrogen bonds, to octane, one of the non-polar hydrocarbons that makes up gasoline. They have fairly similar boiling points (water = 100 °C, octane = between 99 °C and 126 °C, depending on the isomer), even though water has hydrogen bonding and octane only experiences London dispersion forces. This because octane is a much larger molecule with more electrons and therefore stronger dispersion forces – strong enough to compare with the hydrogen bonding experienced between water molecules.
Related resources from AACT Library that may be used to prepare for or further teach this topic:
  o Lesson Plan: Polarity
  o Lab: Shapes of Molecules (only includes molecules that follow the octet rule)
  o Activity: VSPER with Balloons (includes molecules that are exceptions to the octet rule)
  o Demonstration: Intermolecular Forces & Physical Properties
  o Lab: Physical Properties (High School)
  o Simulation Activity: Comparing Attractive Forces
  o Activity: Properties of Common Molecular Substances

Additional resources that might be helpful:
  o https://www.khanacademy.org/test-prep/mcat/chemical-processes/covalent-bonds/a/intramolecular-and-intermolecular-forces and related videos on electronegativity and intermolecular forces
  o https://phet.colorado.edu/en/simulation/molecule-shapes
  o https://phet.colorado.edu/en/simulation/molecule-polarity