Edgenuity

Warm-Up | Intermolecular Forces

Lesson Objectives

By the end of this lesson, you should be able to:

- Describe hydrogen bonding.
- Describe van der Waals forces, including dipole–dipole forces and London dispersion forces.
- Describe how hydrogen bonding and van der Waals forces affect the volatility, boiling points, and melting points of liquids and solids.

Science Practice: Give examples of intermolecular forces occurring in nature.

Words to Know

Write the letter of the definition next to the matching word as you work through the lesson. You may use the glossary to help you.

C intermolecular forces

A hydrogen bond

D formula unit

B Van der Waals forces

F London dispersion forces

E intramolecular forces

A. the attractive interaction of a hydrogen atom with an electronegative atom

B. the attractive or repulsive forces between molecules (or between regions of the same molecule) that are the result of a random, short-lived redistribution of electrons throughout the molecule

C. the attractive or repulsive forces that act between molecules in a substance

D. an electrically neutral group of ions joined by ionic bonds; the smallest unit of an ionic compound

E. the forces that hold a molecule together

F. the Van der Waals forces that cause temporary attraction between molecules

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Lesson Question

What types of forces exist between molecules, and how do these forces affect the properties of the molecule?

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Intramolecular vs. Intermolecular Forces

Intramolecular forces

- Act *within* a molecule
- Hold a molecule together (chemical bonds)
- Classified into following types:
  - Covalent bonds
  - Ionic bonds

Intermolecular forces

- Attractive or repulsive forces that act *between* molecules in a substance
- Affect interactions between molecules
- Classified into following types:
  - Hydrogen bonds
  - London dispersion forces
  - Van der Waals forces

Intermolecular forces are much weaker than chemical bonds.

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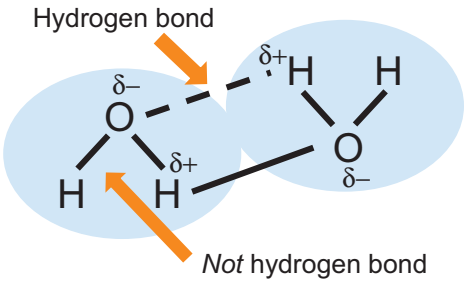
Hydrogen Bonds

Hydrogen bond: the attraction between H bonded to an electronegative atom and an electronegative atom of a *different* molecule

- Can also be different region of the same large molecule



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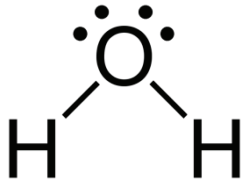
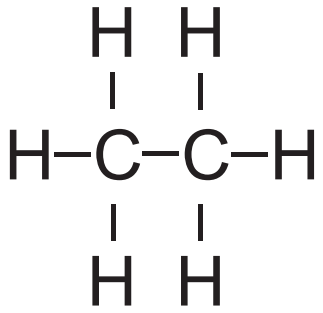
Hydrogen Bonding and Properties Example

Water



Ethane



Hydrogen bonding affects the properties of substances that exhibit it. For example, the structure of [water] has hydrogen bonding while ethane does not have hydrogen bonding.

Water molecules:

- Strong hydrogen bonding between H and [O]; relatively high melting, boiling points
- High surface tension, viscosity
- Dissolves many [ionic], polar covalent substances
- Solid water (ice) less dense than liquid [water]

Ethane molecules:

- No hydrogen bonding: [low] melting, boiling points (gas at room temperature)
- [Low] surface tension, viscosity
- Dissolves only nonpolar covalent substances
- Solid ethane more dense than liquid ethane

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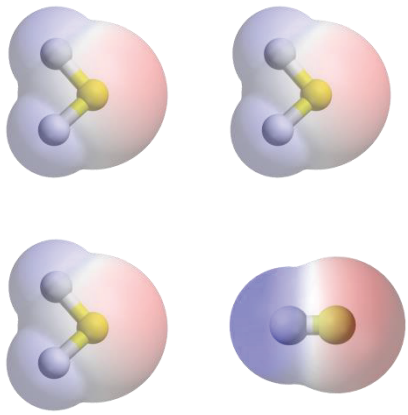
Van der Waals Forces

Van der Waals forces: attractive or repulsive intermolecular forces that are the result of random, short-lived redistribution of electrons

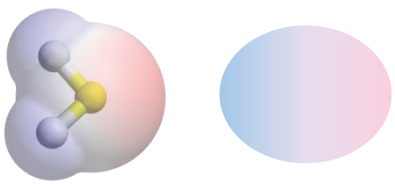
- Dipole-dipole interactions
  - Interactions between polar molecules
  - Positive poles attracting negative poles



Dipole-Induced Dipole Interactions

Dipole-Induced Dipole Interaction defined as:

- Interactions between polar and nonpolar molecules
- Polar molecule induces charge redistribution in nonpolar molecule



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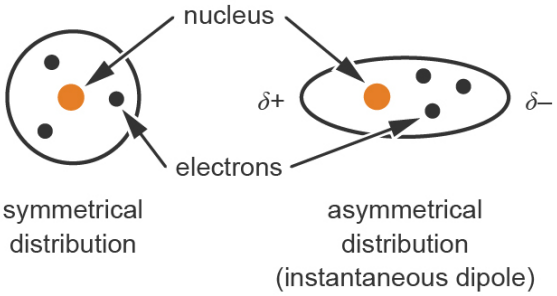
London Dispersion Forces

London dispersion forces: Van der Waals forces that cause molecules to be temporarily [attracted] to one another



- Induced dipole-induced dipole interaction
  - Are a result of the asymmetrical distribution of [electrons]
  - Are the [weakest] intermolecular forces
  - Will affect all substances; important only in nonpolar substances

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Gecko Feet: Van der Waals Forces

A gecko can stick to glass and other smooth surfaces because of the structure of its [feet].

- The feet are covered with millions of tiny [hairs].
  - Each hair splits into tips ~2×10^{-7} m.
  - Van der Waals forces between hair tips and surface = [adhesive] force.

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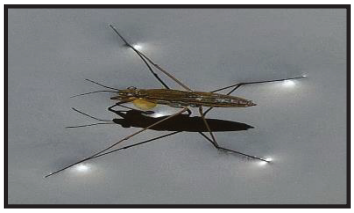
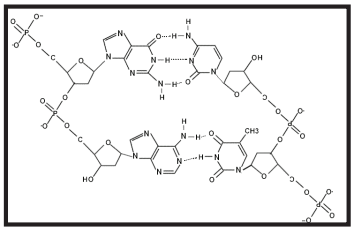
Water Striders and DNA: Hydrogen Bonding

Hydrogen bonding:

- Produces high surface [tension]
  - Can support small objects: insects, paperclips, and so on
- Holds the two sides of [molecules] together
- Is also important in [protein] structure

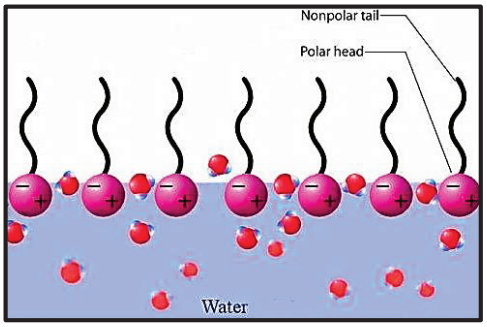




Soap: Van der Waals Interactions

Dish soap:

- Grease/Fat = [nonpolar]
  - Is [insoluble] in water
- Soap = ionic end and nonpolar end
  - Makes grease “soluble” in [water]



Summary | Intermolecular Forces

Lesson Question

What types of forces exist between molecules, and how do these forces affect the properties of the molecule?

Answer

(Sample answer) There are several types of intermolecular forces that exist between molecules. The main forces are hydrogen bonding and Van der Waals forces. Such forces affect many properties of the molecule like surface tension, melting point, viscosity, and density.

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Types of Intermolecular Forces

Intermolecular forces act between molecules or between separate regions of the same molecule.

- Hydrogen bonding is an [electrostatic] attraction between a hydrogen atom and a highly electronegative atom.
- Van der Waals forces are electrostatic interactions between partially [charged] regions of a molecule.
  - Dipole−dipole interactions occur between polar molecules.
  - Dipole-induced dipole interactions occur between polar and nonpolar molecules.
  - London dispersion forces occur in all substances, but are most important in [nonpolar] substances.

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Applications of Intermolecular Forces

Interactions between molecules have many observable effects.

- Many animals use van der Waals forces to "stick" to surfaces.
- Many of water's unique properties, including surface tension, melting point, and density, are the result of hydrogen bonding.
- Common technologies, such as soap, make use of intermolecular forces.

Use this space to write any questions or thoughts about this lesson.