

Unit Lesson Plan – Intermolecular (IM) Forces

Teacher:	<Teacher>	Time Frame:	9 days
Grade:	10	School:	<School>
Subject:	PSI Chemistry		

NGSS DCI:	<ul style="list-style-type: none"> 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. [Clarification Statement: Emphasis is on understanding the strengths of forces between particles, not on naming specific intermolecular forces (such as dipole-dipole). Examples of particles could include ions, atoms, molecules, and networked materials (such as graphite). Examples of bulk properties of substances could include the melting point and boiling point, vapor pressure, and surface tension.] [Assessment Boundary: Assessment does not include Raoult's law calculations of vapor pressure.]
AP Standards:	<ul style="list-style-type: none"> Essential knowledge 2.A.1: The different properties of solids and liquids can be explained by differences in their structures, both at the particulate level and in their supramolecular structures. Essential knowledge 2.B.1: London dispersion forces are attractive forces present between all atoms and molecules. London dispersion forces are often the strongest net intermolecular force between large molecules. Essential knowledge 2.B.2: Dipole forces result from the attraction among the positive ends and negative ends of polar molecules. Hydrogen bonding is a strong type of dipole-dipole force that exists when very electronegative atoms (N, O, and F) are involved. Essential knowledge 2.B.3: Intermolecular forces play a key role in determining the properties of substances, including biological structures and interactions. Learning Objective 2.1 Students can predict properties of substances based on their chemical formulas, and provide explanations of their properties based on particle views. Learning Objective 2.3 The student is able to use aspects of particulate models (i.e., particle spacing, motion, and forces of attraction) to reason about observed differences between solid and liquid phases and among solid and liquid materials. Learning Objective 2.7 The student is able to explain how solutes can be separated by chromatography based on intermolecular interactions. Learning Objective 2.10 The student can design and/or interpret the results of a separation experiment (filtration, paper chromatography, column chromatography, or distillation) in terms of the relative strength of interactions among and between the components. Learning Objective 2.11 The student is able to explain the trends in properties and/or predict properties of samples consisting of particles with no permanent dipole on the basis of London dispersion forces. Learning Objective 2.13 The student is able to describe the relationships between the structural features of polar molecules and the forces of attraction between the particles.

Note that this **exact** Smart Notebook presentation has not been used in the classroom, although all of the material has. The pacing below is approximate based on a 40-45 minute class period. Feel free to adjust as necessary and please provide your feedback!

	<ul style="list-style-type: none">• Learning Objective 2.15 The student is able to explain observations regarding the solubility of ionic solids and molecules in water and other solvents on the basis of particle views that include intermolecular interactions and entropic effects.• Learning Objective 2.16 The student is able to explain the properties (phase, vapor pressure, viscosity, etc.) of small and large molecular compounds in terms of the strengths and types of intermolecular forces.• Learning Objective 2.18 The student is able to rank and justify the ranking of bond polarity on the basis of the locations of the bonded atoms in the periodic table.• Learning Objective 2.22 The student is able to design or evaluate a plan to collect and/or interpret data needed to deduce the type of bonding in a sample of a solid.• Learning Objective 2.23 The student can create a representation of an ionic solid that shows essential characteristics of the structure and interactions present in the substance.• Learning Objective 2.24 The student is able to explain a representation that connects properties of an ionic solid to its structural attributes and to the interactions present at the atomic level.• Learning Objective 2.27 The student can create a representation of a metallic solid that shows essential characteristics of the structure and interactions present in the substance.• Learning Objective 2.28 The student is able to explain a representation that connects properties of a metallic solid to its structural attributes and to the interactions present at the atomic level.• Learning Objective 2.29 The student can create a representation of a covalent solid that shows essential characteristics of the structure and interactions present in the substance.• Learning Objective 2.30 The student is able to explain a representation that connects properties of a covalent solid to its structural attributes and to the interactions present at the atomic level.• Learning Objective 2.31 The student can create a representation of a molecular solid that shows essential characteristics of the structure and interactions present in the substance• Learning Objective 2.32 The student is able to explain a representation that connects properties of a molecular solid to its structural attributes and to the interactions present at the atomic level.
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Essential Questions

(What questions will the student be able to answer as a result of the instruction?)

At a molecular level, how do gases, liquids and solids compare?

What role do temperature and IM forces play in the determining the physical state of a substance?

What is meant by the boiling point of a liquid?

How do the nature and strengths of the IM forces between molecules impact on the boiling point?

What is the vapor pressure of a liquid and how does the nature and strengths of the IM forces between molecules affect the vapor pressure?

How does the boiling point of a substance relate to its vapor pressure?

What does it mean for a liquid to be volatile or to evaporate?

Why is evaporation a cooling process?

What are phase diagrams and what do they represent?

Knowledge & Skills

(What skills are needed to achieve the desired results?)

By the end of this unit, students will know:

- The 2 fundamental differences between states of matter are the distance between particles and the particles' freedom to move.
- Solids and liquids are considered condensed phases of matter.
- The state of a substance at a particular temperature and pressure depends on two major factors: the strength of the intermolecular forces that hold molecules together and the kinetic energy of the molecules.
- The attractions between molecules, intermolecular forces, are not nearly as strong as the intramolecular attractions that hold compounds together.
- Without intermolecular forces (IMF's), all substances would behave like ideal gases, there would be no liquids or solids.
- Temperature is directly proportional to the average kinetic energy of the molecules that make up a substance.
- The boiling point of a substance refers to the temperature at which the molecules' energy overcomes the intermolecular forces binding them together.
- The higher the boiling point of a substance, the stronger the intermolecular forces.
- The concept of polarizability and how it relates to dispersion forces.
- The relationship between physical properties viscosity and surface tension and a substance's intermolecular forces.
- That phase changes are transformations from one phase to another.
- Melting, sublimation and vaporation are endothermic process and freezing, deposition and condensation are exothermic processes
- The vapor pressure of a liquid indicates the tendency of the liquid to evaporate and is inversely proportional to the strength of its intermolecular forces. The greater the IM forces present the lower its vapor pressure.
- A phase diagram depicts the equilibria that exist between the solid, liquid and gas phases of

By the end of this unit, students will be able to:

- Compare and contrast the physical properties of gases, liquids and solids as they relate to the IM forces and the relative strengths of intermolecular attractive forces.
- Identify the intermolecular attractive forces (dipole-dipole, London dispersion and hydrogen bonds) that exists between molecules or ions based on their composition and molecular structure and compare the relative strengths of these forces.
- Outline the relationship between the strength of intermolecular forces present and a substance's volatility, viscosity and surface tension.
- Predict the relative boiling points of different substances from an understanding of their intermolecular forces.
- Describe all phase changes as either endothermic or endothermic processes.
- Be able to draw and interpret a phase diagram and be able to determine the phase change a substance goes through as temperature or pressure are varied.
- Use the slope of the melting curve to predict whether the liquid or the solid phase of the substance is denser.
- Define critical temperature, critical pressure, vapor pressure, normal boiling and melting point, critical point and triple point.
- Explain how water's phase diagram differs from most other substances.
- Classify solids based on their bonding/intermolecular forces and understand how differences in bonding relates to physical properties.

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<p>substances as a function of temperature and pressure.</p> <ul style="list-style-type: none"> • A line indicates the equilibria between any two states. • The normal melting or boiling point is at 1 atm of pressure. • The point on the diagram when all three phases are in equilibrium is called the triple point. • Know the difference between crystalline and amorphous solids. 	
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Assessment

(What is acceptable evidence to show desired results (rubrics, exam, etc.)? Attach Copy

During the Smart Notebook lesson designed to introduce concepts, students will be continually questioned on these concepts using a combination of class work/homework questions and the SMART Response system. Classwork and Homework questions will be discussed as a class and misconceptions will be addressed by the teacher prior to the formal evaluations listed below.

Intermolecular Forces Quiz
 Vapor Pressure Quiz
 Phase Diagrams Quiz
 Intermolecular Forces Test

Other assessments on the NJCTL website are optional and can be used as needed.

(What is the sequence of activities, learning experiences, etc, that will lead to desired results (the plan)?

Day	Topic	Classwork	Homework**
1	States of Matter and Intermolecular Forces	1-4,9-10	5-8,11-12
2	Types of Intermolecular Forces: Dipole-Dipole and London Dispersion Forces	15-18	19-21

3	Types of Intermolecular Forces: Hydrogen bonding and Ion-dipole	22-30	31-40
4	Intermolecular Forces Quiz + IMFs and Physical Properties and Phase Changes	41-42	43-45
5	Vaporization/Vapor Pressure	46-50	51-56
6	Vapor Pressure Quiz + Phase Diagrams	57-64	65-73
7	Phase Diagrams Quiz + Types of Solids	74-77	78-81
8	Exam Review		
9	Intermolecular Forces Test		

* It may not be possible to complete labs in the order stated due to lab schedules. Other labs on the NJCTL website are option and can be used as needed.

**HW Problems are currently not scaffolded from least to most difficult, but are instead listed in order of topic. Teacher should pay special attention at the end of each class period when assigning HW so that only problems related to the topic that was taught are being assigned.