11 - States of Matter and Phase Changes

Content Area: **Science**
Course(s):
Time Period: **Full Year**
Length: **7 Blocks**
Status: **Published**

General Overview, Course Description or Course Philosophy

Chemistry CP aims to provide students with a fundamental understanding of the composition, structure, properties, and transformations of matter. Through a combination of theoretical concepts, laboratory investigations, and real-world applications, students will explore the principles and laws that govern chemical reactions and interactions. The course emphasizes the development of scientific inquiry skills, critical thinking abilities, and the application of problem-solving strategies. Students will actively engage in the process of scientific discovery, asking questions, seeking answers, and making connections between theory and practical applications. Laboratory experiences will integrate with theoretical knowledge, fostering the development of practical skills, scientific inquiry, and responsible practices. Students will also explore the ethical considerations and societal implications of chemistry, promoting informed decision-making as responsible citizens. By the end of the course, students will have a deepened appreciation for the relevance of chemistry in everyday life and will be prepared for further study and careers in scientific fields.

OBJECTIVES, ESSENTIAL QUESTIONS, ENDURING UNDERSTANDINGS

Objectives:

- Define and describe the characteristics and properties of solids, liquids, and gases.
- Explain the behavior of particles in different states of matter in terms of intermolecular forces, energy, and temperature.
- Identify and describe the different phase changes, including melting, freezing, evaporation, condensation, sublimation, and deposition.
- Relate the energy changes associated with phase changes to the breaking or formation of intermolecular forces.
- Interpret and analyze phase diagrams to determine the state(s) of matter at given temperature and pressure conditions.
- Apply the concept of phase changes to real-world examples, such as cooking, weather phenomena, and industrial processes.
- Conduct experiments and observations to investigate and demonstrate phase changes and their effects.
- Analyze and interpret data and graphs related to states of matter and phase changes.
- Communicate scientific ideas and findings effectively, using appropriate terminology and models.
- Recognize and appreciate the importance of states of matter and phase changes in various scientific fields and everyday life.

Essential Questions:

- What are the different states of matter, and what are their unique properties and behaviors?
- How do intermolecular forces and energy influence the behavior of particles in different states of matter?
- What are phase changes, and what energy changes occur during these transitions?

- How can the phase diagram be used to understand the relationships between temperature, pressure, and the states of matter?
- In what ways are states of matter and phase changes relevant and applicable in everyday life and scientific fields?

Enduring Understandings:

- Matter can exist in different states: solid, liquid, and gas, with distinct properties and behaviors.
- The behavior of particles in different states of matter is influenced by factors such as intermolecular forces, energy, and temperature.
- Phase changes involve the transition between different states of matter and are accompanied by energy changes.
- The phase diagram provides a graphical representation of the relationships between temperature, pressure, and the states of matter.
- The understanding of states of matter and phase changes has practical applications in various fields, including materials science and environmental science.

CONTENT AREA STANDARDS

SCI.9-12.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.
SCI.9-12.HS-PS3-4	Plan and conduct an investigation to provide evidence that the transfer of thermal energy when two components of different temperature are combined within a closed system results in a more uniform energy distribution among the components in the system (second law of thermodynamics).
SCI.9-12.HS-PS3-1	Create a computational model to calculate the change in the energy of one component in a system when the change in energy of the other component(s) and energy flows in and out of the system are known.

RELATED STANDARDS (Technology, 21st Century Life & Careers, ELA Companion Standards are Required)

MA.N-Q.A.1	Use units as a way to understand problems and to guide the solution of multi-step problems; choose and interpret units consistently in formulas; choose and interpret the scale and the origin in graphs and data displays.
MA.N-Q.A.3	Choose a level of accuracy appropriate to limitations on measurement when reporting quantities.
TECH.K-12.1.3.d	build knowledge by actively exploring real-world issues and problems, developing ideas and theories and pursuing answers and solutions.
LA.RST.9-10.1	Accurately cite strong and thorough evidence from the text to support analysis of science and technical texts, attending to precise details for explanations or descriptions.
LA.RST.9-10.2	Determine the central ideas, themes, or conclusions of a text; trace the text's explanation or depiction of a complex process, phenomenon, or concept; provide an accurate summary of the text.
TECH.K-12.1.4.a	know and use a deliberate design process for generating ideas, testing theories, creating

	innovative artifacts or solving authentic problems.
LA.RST.9-10.7	Translate quantitative or technical information expressed in words in a text into visual form (e.g., a table or chart) and translate information expressed visually or mathematically (e.g., in an equation) into words.

STUDENT LEARNING TARGETS

Refer to the 'Declarative Knowledge' and 'Procedural Knowledge sections.

Declarative Knowledge

Students will understand that:

- The kinetic molecular theory can be used to explain the properties of solids, liquids, and gases, and that changing between them involves the flow of energy.
- Temperature is a measure of the average kinetic energy for the molecules/atoms in a substance.
- Heat flow is the energy transfer between objects due to a temperature difference between them.
- A heating diagram can be used to visualize the energy involved in the conversion between the three phases.
- For a liquid in a closed container, evaporation and condensation happen at the same rate (dynamic equilibrium).
- Intermolecular forces and intramolecular forces vary widely in strength but can be predicted. [Honors]
- The strength of intermolecular forces can be used to determine the melting point, boiling point, vapor pressure, or volatility of a substance. [Honors]

Procedural Knowledge

Students will be able to:

- Identify and describe the components to be computationally modeled, including:
    - The boundaries of the system and the reference level for potential energy = 0 (the potential energy of the initial or final state does not have to be zero);
    - The initial energies of the system's components (e.g., energy in fields, thermal energy, kinetic energy, energy stored in springs — all expressed as a total amount of Joules in each component), including a quantification in an algebraic description to calculate the total initial energy of the system;
    - The energy flows in or out of the system, including a quantification in an algebraic description with the flow into the system defined as positive; and
    - The final energies of the system components, including a quantification in an algebraic description to calculate the total final energy of the system.
- Develop an investigation plan and describe the data that will be collected and the evidence to be derived from the data, including:
    - The measurement of the reduction of temperature of the hot object and the increase in temperature of the cold object shows that the thermal energy lost by the hot object is equal to

the thermal energy gained by the cold object and that the distribution of thermal energy is more uniform after the interaction of the hot and cold components; and
    - The heat capacity of the components in the system (obtained from scientific literature).
- Describe why the data about bulk properties would provide information about the strength of the electrical forces between the particles of the chosen substances, including the following descriptions:
    - The spacing of the particles of the chosen substances can change as a result of the experimental procedure even if the identity of the particles does not change (e.g., when water is boiled the molecules are still present but further apart).
    - Thermal (kinetic) energy has an effect on the ability of the electrical attraction between particles to keep the particles close together. Thus, as more energy is added to the system, the forces of attraction between the particles can no longer keep the particles close together.
    - The patterns of interactions between particles at the molecular scale are reflected in the patterns of behavior at the macroscopic scale.
    - Together, patterns observed at multiple scales can provide evidence of the causal relationships between the strength of the electrical forces between particles and the structure of substances at the bulk scale.

EVIDENCE OF LEARNING

Refer to the 'Formative Assessments' and 'Summative Assessments' sections.

Formative Assessments

- POGIL Activities:
    - Saturated and Unsaturated Solutions
    - Solubility
- Labs
    - It’s in Their Nature (Solubility and Intermolecular Forces)
    - Polymer Chemistry
- Group practice
    - Kinetic Molecular Theory of Solids, Liquids, and Gases
    - Temperature and Pressure Conversions
    - Boiling Point and Vapor Pressure
    - Phase Diagrams
- Performance Scale/ Student Tracking Chart
- Whiteboards
- Exit Tickets
- Homework

Summative Assessments

- Benchmarks – departmental benchmark given at the end of MP1, MP2, and MP3 based on lab practices
- Alternative Assessments
    - Lab inquiries and investigations
    - Lab Practicals
    - Exploratory activities based on phenomenon
    - Gallery walks of student work
    - Creative Extension Projects
    - Build a model of a proposed solution
    - Let students design their own flashcards to test each other
    - Keynote presentations made by students on a topic
    - Portfolio
- Heat and Phase Changes Test
- Solubility and Intermolecular Forces Lab Report

RESOURCES (Instructional, Supplemental, Intervention Materials)

CK-12 Online Textbook

POGIL Chemistry

Gizmos Simulations

PhET Simulations

Khan Academy

Bozeman Science

American Chemical Society

INTERDISCIPLINARY CONNECTIONS

ELA/Literacy

Mathematics

Technology

ACCOMMODATIONS & MODIFICATIONS FOR SUBGROUPS

See link to Accommodations & Modifications document in course folder.