Unit/Concept Title: **States of Matter, Gases**

Estimated Time (When): **6 blocks** **Modern Chemistry Chapters 10 & 11**

Standard(s): Physical Science
Prepared Graduates: • 1. Students can use the full range of science and engineering practices to make sense of natural phenomena and solve problems that require understanding structure, properties and interactions of matter. • 3. Students can use the full range of science and engineering practices to make sense of natural phenomena and solve problems that require understanding how energy is transferred and conserved. **Grade Level Expectation:** • 2. Chemical processes, their rates, their outcomes, and whether or not energy is stored or released can be understood in terms of collisions of molecules, rearrangement of atoms, and changes in energy as determined by properties of elements involved. • 6. Energy is a quantitative property of a system that depends on the motion and interactions of matter and radiation within that system.

The highlighted evidence outcomes are the priority for all students, serving as the essential concepts and skills. Evidence outcomes in the 2020 Colorado Academic Standards for Science were intentionally designed to be priority standards representing the full breadth of the curriculum.

Evidence Outcomes: Students Can	**Academic Context and Connections**
2a. Construct and revise an explanation for the outcome of a simple chemical reaction based on the outermost electron states of atoms, trends in the periodic table, and knowledge of the patterns of chemical properties. **(HS-PS1-2)** *(Clarification Statement: Examples of chemical reactions could include the reaction of sodium and chlorine, of carbon and oxygen, or of carbon and hydrogen.) (Boundary Statement: Limited to chemical reactions involving main group elements and combustion reactions).* *2b.* Develop a model to illustrate that the release or absorption of energy from a chemical reaction system depends upon the changes	**Colorado Essential Skills and Science and Engineering Practices:** 1. Construct and revise an explanation based on valid and reliable evidence obtained from a variety of sources (including students' own investigations, models, theories, simulations, peer review) and the assumption that theories and laws that describe the natural world operate today as they did in the past and will continue to do so in the future. Apply scientific principles and evidence to provide an explanation of phenomena and solve design problems, taking into account possible unanticipated effects. Refine a solution to a complex real-world problem, based on scientific knowledge, student-generated sources of evidence, prioritized criteria, and trade-off considerations. (Constructing Explanations and Designing

in total bond energy. **(HS-PS1-4)** *(Clarification Statement: Emphasis is on the idea that a chemical reaction is a system that affects the energy change. Examples of models could include molecular-level drawings and diagrams of reactions, graphs showing the relative energies of reactants and products, and representations showing energy is conserved.) (Boundary Statement: Does not include calculating the total bond energy changes during a chemical reaction from the bond energies of reactants and products.)*

2c. Apply scientific principles and evidence to provide an explanation about the effects of changing the temperature or concentration of the reacting particles on the rate at which a reaction occurs. **(HS-PS1-5)** *(Clarification Statement: Emphasis is on student reasoning that focuses on the number and energy of collisions between molecules.) (Boundary Statement: Limited to simple reactions in which there are only two reactants; evidence from temperature, concentration, and rate data; and qualitative relationships between rate and temperature.)*

2d. Refine the design of a chemical system by specifying a change in conditions that would produce increased amounts of products at equilibrium. **(HS-PS1-6)** *(Clarification Statement: Emphasis is on the application of Le Chatlier's Principle and on refining designs of chemical reaction systems, including descriptions of the connection between changes made at the macroscopic level and what happens at the molecular level. Examples of designs could include different ways to increase product formation including adding reactants or removing products.) (Boundary Statement: Limited to specifying the change in only one variable at a time. Does not include calculating equilibrium constants and concentrations.)*

Solutions) (Civic/Interpersonal: Civic Engagement)

2. Develop a model based on evidence to illustrate the relationships between systems or between components of a system (Developing and Using Models) (Personal: Personal responsibility)
3. Use mathematical representations of phenomena to support claims (Using Mathematics and Computational Thinking) (Entrepreneurial: Critical thinking/Problem solving)
4. Develop and use a model based on evidence to illustrate the relationships between systems or between components of a system. (Developing and Using Models) (Personal: Personal responsibility)
5. Create a computational model or simulation of a phenomenon, designed device, process, or system. (Using Mathematics and Computational Thinking) (Entrepreneurial: Critical thinking/Problem solving)

Elaboration on the GLE:

1. Students can answer the questions: How do substances combine or change (react) to make new substances? How does one characterize and explain these reactions and make predictions about them?
2. PS1:B Chemical Reactions: Chemical processes, their rates, and whether or not energy is stored or released can be understood in terms of the collisions of molecules and the rearrangements of atoms into new molecules, with consequent changes in the sum of all bond energies in the set of molecules that are matched by changes in kinetic energy. In many situations, a dynamic and condition-dependent balance between a reaction and the reverse reaction determines the numbers of all types of molecules present. The fact that atoms are conserved, together with knowledge of the chemical properties of the elements involved, can be used to describe and predict chemical reactions.
3. Students can answer the question: What is energy?
4. PS3:A Definitions of Energy: Energy is a quantitative property of

2e. Use mathematical representations to support the claim that atoms, and therefore mass, are conserved during a chemical reaction. **(HS-PS1-7)** *(Clarification Statement: Emphasis is on using mathematical ideas to communicate the proportional relationships between masses of atoms in the reactants and the products, and the translation of these relationships to the macroscopic scale using the mole as the conversion from the atomic to the macroscopic scale. Emphasis is on assessing students' use of mathematical thinking and not on memorization and rote application of problem-solving techniques.) (Boundary Statement: Does not include complex chemical reactions or calculations involving limiting and excess reactants.)*

6a. *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.* ***(HS-PS3-1)*** *(Clarification Statement: Emphasis is on explaining the meaning of mathematical expressions used in the model.) (Boundary Statement: Limited to basic algebraic expressions or computations; to systems of two or three components; and to thermal energy, kinetic energy, and/or the energies in gravitational, magnetic, or electric fields.)*

6b. *Develop and use models to illustrate that energy at the macroscopic scale can be accounted for as a combination of energy associated with the motion of particles (objects) and energy associated with the relative positions of particles (objects).* ***(HS-PS3-2)*** *(Clarification Statement: Examples of phenomena at the macroscopic scale could include the conversion of kinetic energy to thermal energy, the energy stored due to position of an object above the Earth, and the energy stored between two electrically charged plates. Examples of models could include diagrams, drawings, descriptions, and*

a system that depends on the motion and interactions of matter and radiation within that system. That there is a single quantity called energy is due to the fact that a system's total energy is conserved, even as, within the system, energy is continually transferred from one object to another and between its various possible forms. At the macroscopic scale, energy manifests itself in multiple ways, such as in motion, sound, light, and thermal energy. These relationships are better understood at the microscopic scale, at which all of the different manifestations of energy can be modeled as a combination of energy associated with the motion of particles and energy associated with the configuration (relative position of the particles). In some cases the relative position energy can be thought of as stored in fields (which mediate interactions between particles). This last concept includes radiation, a phenomenon in which energy stored in fields moves across space.

Cross Cutting Concepts:

1. Patterns: Different patterns may be observed at each of the scales at which a system is studied and can provide evidence for causality in explanations of phenomena.
2. Energy and Matter: Changes of energy and matter in a system can be described in terms of energy and matter flows into, out of, and within that system.
3. Stability and Change: Much of science deals with constructing explanations of how things change and how they remain stable.
4. Connections to Nature of Science: Scientific Knowledge Assumes an Order and Consistency in Natural Systems. Science assumes the universe is a vast single system in which basic laws are consistent.
5. System and System Models: Models can be used to predict the behavior of a system, but these predictions have limited precision and reliability due to the assumptions and approximations inherent in

computer simulations.) 6c. *Design, build, and refine a device that works within given constraints to convert one form of energy into another form of energy.* ***(HS-PS3-3)*** *(Clarification Statement: Emphasis is on both qualitative and quantitative evaluations of devices and on the ability of energy to be transferred but not on the efficiency of energy transfer. Examples of devices could include Rube Goldberg devices, wind turbines, solar cells, solar ovens, and generators. Examples of constraints could include use of renewable energy forms and efficiency.) (Boundary Statement: Quantitative evaluations are limited to total output for a given input, and are limited to devices constructed with materials provided to students.)*	models. 6. Constructing Explanations and Designing Solutions: Design, evaluate, and/or refine a solution to complex real-world problem, based on scientific knowledge, student-generated sources of evidence, prioritized criteria, and trade-off considerations. 7. Energy and Matter: Changes of energy and matter in a system can be described in terms of energy and matter flows into, out of, and within that system. Energy cannot be created or destroyed — only moves between one place and another place, between objects and/or fields, or between systems. 8. Connections to Engineering, Technology, and Applications of Science: Influence of Science, Engineering, and Technology on Society and the Natural World. Modern civilization depends on major technological systems. Engineers continuously modify these technological systems by applying scientific knowledge and engineering design practices to increase benefits while decreasing costs and risks. 9. Connections to Nature of Science: Scientific Knowledge Assumes an Order and Consistency in Natural Systems. Science assumes the universe is a vast single system in which basic laws are consistent.

Teacher Notes

Highlighted Numbers in the Evidence Outcomes ***(HS-PS3-1)*** above are the NGSS Correlation to the Colorado Academic Science Standards

Instructional Resources

St. Vrain Instructional Resources - Find resources including HMH instructional materials, science literacy connections, science notebook starters, essential vocabulary, unit assessments, STEM connections, environmental Education connections and teaching about climate resources.

Science Assessment Resources - CMAS / SAT