



Unit 1 - Counting Particles

Draft Date 07-15-2024	Course HS H/CP/GEN Chemistry	Duration 3 Week(s)	Grades 10, 11, 12	Subjects Science	Team Matthew Fox, Adam Miller, Dylan Tull, Ashley Johnston
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Focus

We can't see these atoms, so how do scientists know that water is made of hydrogen and oxygen? Like early chemists, we can use relative masses of atoms to count particles by weighing. These "moles" allow us to examine the composition of different substances.

Stage 1: Learning Goals

Established Goals	Transfer	
Standards	Long-Term Transfer Goals	
Pennsylvania Academic Standards Science (2023): 9-12 Standards ■ Use mathematical representations to support the claim that atoms, and therefore mass, are conserved during a chemical reaction. Clarifying 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.	What kinds of long-term, independent accomplishments are desired? Students will be able to independently use their learning to... ■ Approach science as a reliable and testable way of knowing and explaining the natural world and designed world. (Life-Long Learner) (T1) ■ Weigh evidence and use scientific approaches to ask questions, investigate, and make informed decisions. (Innovative Problem Solver) (T2) ■ Make and use observations to analyze relationships and patterns in order to explain phenomena, develop models, and make predictions. (Communicator) (T3) ■ Participate in respectful discourse with peers, teachers, and experts in the field to share ideas, perspectives, and findings. (Collaborator, Communicator) (T4)	
	Meaning	
	Understandings	Essential Questions
	What specifically do you want students to understand? What inferences should they make? Students will understand that... ■ Moles are used to count the amount of particles in a given substance using the relative masses of different atoms. (U1)	What thought-provoking questions will foster inquiry, meaning making, and transfer? Students will keep considering... ■ How do we use moles to determine the amount of particles in a given substance? (Q1)

Assessment Boundary: Assessment does not include complex chemical reactions. (3.2.9-12.G)

Profile of a CV Learner

- Collaboration: Students will be able to independently engage and meaningfully contribute to a team to reach a common goal, through mutual reflection, feedback, and shared responsibility. (PCVL.CO)
- Innovative Problem Solving: Students will be able to independently use their learning to approach new problems with curiosity and creativity while consistently seeking growth through self-reflection and a willingness to accept constructive feedback. (PCVL.IPS)

- Experiments can be used to collect macroscopic observations to construct microscopic inferences. This cycle continues until these inferences are accepted as conclusions. (U2)
- Teams work efficiently and effectively when members share leadership and decision-making responsibilities. (U3)
- Innovative problem-solvers realize that failure is an opportunity to learn and accept constructive feedback to evaluate and revise their thinking. (U4)

- How do we perform experiments when microscopic chemical interactions cannot be observed directly? (Q2)
- What makes a group effective? How are we working together right now? How can we continue to improve to meet a common goal? (Q3)
- How can we approach learning even when our first attempt was not successful? (Q4)

Acquisition of Knowledge & Skill

Knowledge

What facts and basic concepts should students know and be able to recall?
Students will know...

- One mole is defined as the atomic mass of any given element in grams. (K1)
- The molar mass of any given compound is the sum of the atomic mass for each element in grams. (K2)
- Empirical formulas represent the simplest whole number mole ratio for the given compound. (K3)
- Molecular formulas represent the actual composition of individual molecules for the given compound. (K4)

Skills

What discrete skills and processes should students be able to use? Students can...

- I can determine the mass for a given substance using moles and the molar mass of the substance. (S1)
- I can determine the moles for a given substance using mass and the molar mass of the substance. (S2)
- I can determine empirical formulas from experimental data. (S3)
- I can relate the empirical formula to its corresponding molecular formulas using the molar mass of the substance. (S4)



Unit 2 - Internal Structure

Draft Date 07-15-2024	Course HS H/CP/GEN Chemistry	Duration 3 Week(s)	Grades 10, 11, 12	Subjects Science	Team Adam Miller, Matthew Fox, Dylan Tull, Ashley Johnston
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Focus

How can we use chemistry to explore the wide variety of substances used in our society? We will examine basic patterns of bonding based on the internal structure of atoms, rather than simply counting these particles. These differences in structure affect the characteristic properties of these substances leading to innovative ways to meet the needs of our society.

Stage 1: Learning Goals

Established Goals	Transfer
Standards	Long-Term Transfer Goals
Pennsylvania Academic Standards Science (2023): 9-12 Standards ■ 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. Clarifying 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	What kinds of long-term, independent accomplishments are desired? Students will be able to independently use their learning to... ■ Approach science as a reliable and testable way of knowing and explaining the natural world and designed world. (Life-Long Learner) (T1) ■ Weigh evidence and use scientific approaches to ask questions, investigate, and make informed decisions. (Innovative Problem Solver) (T2) ■ Make and use observations to analyze relationships and patterns in order to explain phenomena, develop models, and make predictions. (Communicator) (T3) ■ Evaluate systems, in order to connect how form determines function and how any change to one component affects the entire system. (Global Citizen, Innovative Problem Solver) (T4) ■ Participate in respectful discourse with peers, teachers, and experts in the field to share ideas, perspectives, and findings. (Collaborator, Communicator) (T5)

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. (3.2.9-12.B)

- Communicate scientific and technical information about why the molecular-level structure is important in the functioning of designed materials.

Clarifying Statement: Emphasis is on the attractive and repulsive forces that determine the functioning of the material. Examples could include why electrically conductive materials are often made of metal, flexible but durable materials are made up of long chained molecules, and pharmaceuticals are designed to interact with specific receptors.

Assessment Boundary: Assessment is limited to provided molecular structures of specific designed materials. (3.2.9-12.N)

Science (2023): 9-12 Science & Engineering Practices

- Plan and conduct an investigation individually and collaboratively to produce data to serve as the basis for evidence, and in the design: decide on types, how much, and accuracy of data needed to produce reliable measurements and consider limitations on the precision of the data (e.g., number of trials, cost, risk, time), and refine the design accordingly. (SEP.9-12.P3.B)

Meaning	
Understandings	Essential Questions
What specifically do you want students to understand? What inferences should they make? Students will understand that... ■ Matter can be understood in terms of the types of atoms present and the interactions both between and within atoms. (U1) ■ The molecular structure of substances can be altered to adjust the properties of designed materials to serve specific purposes in our society. (U2) ■ Teams work efficiently and effectively when members share leadership and decision-making responsibilities. (U3) ■ Innovative problem-solvers realize that failure is an opportunity to learn and accept constructive feedback to evaluate and revise their thinking. (U4)	What thought-provoking questions will foster inquiry, meaning making, and transfer? Students will keep considering... ■ How can one explain the structure, properties, and interactions of matter? (Q1) ■ How do the properties of different substances result from the underlying attractions between particles? (Q2) ■ How does the molecular level structure affect the function of designed materials? (Q3) ■ What makes a group effective? How are we working together right now? How can we continue to improve to meet a common goal? (Q4) ■ How can we approach learning even when our first attempt was not successful? (Q5)
Acquisition of Knowledge & Skill	
Knowledge	Skills
What facts and basic concepts should students know and be able to recall? Students will know... ■ The typical properties of ionic and molecular solids (K1) ■ The typical structural characteristics of atomic, molecular, and ionic solids (K2)	What discrete skills and processes should students be able to use? Students can... ■ I can analyze and explain why ionic and molecular solids have different properties. (S1) ■ I can construct the name for different compounds given the compound's formula. (S2)

- Communicate scientific and/or technical information or ideas (e.g. about phenomena and/or the process of development and the design and performance of a proposed process or system) in multiple formats (i.e., orally, graphically, textually, mathematically). (*SEP. 9-12.P8.E*)

Science (2023): 9-12 Crosscutting Concepts

- 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. (*CCC.9-12.C1.A.1*)
- Investigating or designing new systems or structures requires a detailed examination of the properties of different materials, the structures of different components, and connections of components to reveal its function and/or solve a problem. (*CCC. 9-12.C6.A*)

Science (2023): 9-12 Disciplinary Core Ideas

- The structure and interactions of matter at the bulk scale are determined by electrical forces within and between atoms. (*DCI. 9-12.PS1.A.3*)
- Attraction and repulsion between electric charges at the atomic scale explain the structure, properties, and transformations of matter, as well as the contact forces between material objects. (*DCI.9-12.PS2.B.2*)

- I can construct the formula for different compounds given the compound's name. (*S3*)
- I can examine differences in designed materials to explain their functions in our society. (*S4*)

Profile of a CV Learner

- Collaboration: Students will be able to independently engage and meaningfully contribute to a team to reach a common goal, through mutual reflection, feedback, and shared responsibility. (*PCVL.CO*)
- Innovative Problem Solving: Students will be able to independently use their learning to approach new problems with curiosity and creativity while consistently seeking growth through self-reflection and a willingness to accept constructive feedback. (*PCVL.IPS*)



Unit 3 - Chemical Change

Draft Date 07-15-2024	Course HS H/CP/GEN Chemistry	Duration 3 Week(s)	Grades 10, 11, 12	Subjects Science	Team Adam Miller, Matthew Fox, Dylan Tull, Ashley Johnston
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Focus

The moment you have been waiting for! How do substances react with each other? Reactions involve the rearrangement of atoms to form new substances. We will use our understanding about chemical nomenclature to construct balanced equations to communicate these changes. Energy also has an important role in describing these changes.

Stage 1: Learning Goals

Established Goals	Transfer		
Standards	Long-Term Transfer Goals		
Pennsylvania Academic Standards Science (2023): 9-12 Standards ■ 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. Clarifying Statement: Examples of chemical reactions could include the reaction of sodium and chlorine, of carbon and oxygen, or of carbon and hydrogen. Assessment Boundary: Assessment is limited to chemical reactions involving	What kinds of long-term, independent accomplishments are desired? Students will be able to independently use their learning to... ■ Approach science as a reliable and testable way of knowing and explaining the natural world and designed world. (Life-Long Learner) (T1) ■ Weigh evidence and use scientific approaches to ask questions, investigate, and make informed decisions. (Innovative Problem Solver) (T2) ■ Make and use observations to analyze relationships and patterns in order to explain phenomena, develop models, and make predictions. (Communicator) (T3) ■ Participate in respectful discourse with peers, teachers, and experts in the field to share ideas, perspectives, and findings. (Collaborator, Communicator) (T4)		
	Meaning		
	Understandings		
	What specifically do you want students to understand? What inferences should they make? Students will understand that... ■ Atoms of some substances combine or rearrange to form new substances that		

main group elements and combustion reactions.
(3.2.9-12.C)

- Develop a model to illustrate that the release or absorption of energy from a chemical reaction system depends upon the changes in total bond energy.

Clarifying 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.

Assessment Boundary: Assessment does not include calculating the total bond energy changes during a chemical reaction from the bond energies of reactants and products. (3.2.9-12.D)

have different properties.
(U1)

- Many chemical reactions follow patterns that allow for prediction of expected products. (U2)
- Chemical energy is needed to break chemical bonds and is released upon the formation of new chemical bonds. The bond strength correlates with the amount of energy. (U3)
- Writing reports for scientific experiments allow us to effectively communicate our results with any audience. (U4)
- Innovative problem-solvers realize that failure is an opportunity to learn and accept constructive feedback to evaluate and revise their thinking. (U5)

Essential Questions

What thought-provoking questions will foster inquiry, meaning making, and transfer? Students will keep considering...

- How do particles combine to form the variety of substances observed in our society? (Q1)
- How can these reactions be categorized to make predictions about their outcome? (Q2)
- How does energy change when particles interact through chemical reactions? (Q3)
- How can we use writing to communicate the results of our scientific experiments? (Q4)
- How can we approach learning even when our first attempt was not successful? (Q5)

Acquisition of Knowledge & Skill

Profile of a CV Learner

- Communication: Students will be able to independently and confidently adapt their writing and speaking in relation to audience, task, and purpose, as well as practice active listening to understand other perspectives, viewpoints, and cultures. (PCVL.CM)
- Innovative Problem Solving: Students will be able to independently use their learning to approach new problems with curiosity and creativity while consistently seeking growth through self-reflection and a

Knowledge

What facts and basic concepts should students know and be able to recall?
Students will know...

- That balanced chemical reactions follow the Law of Conservation of Mass. (K1)
- The characteristics of the five basic types of chemical reactions. (K2)
- The difference between exothermic and endothermic reactions. (K3)

Skills

What discrete skills and processes should students be able to use? Students can...

- I can balance chemical equations and explain why balancing is necessary. (S1)
- I can model chemical reactions at the microscopic level based on macroscopic observations. (S2)
- I can use the five basic types of chemical reactions to predict products for simple chemical reactions. (S3)

willingness to accept constructive feedback. (PCVL.IPS)

■ I can analyze why some reactions release energy, while others absorb energy. (S4)



Unit 4 - Stoichiometry

Draft Date 07-15-2024	Course HS H/CP/GEN Chemistry	Duration 4 Week(s)	Grades 10, 11, 12	Subjects Science	Team Adam Miller, Matthew Fox, Dylan Tull, Ashley Johnston
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Focus

When we bake cookies, we know how many should be made. Can we predict this for chemical reactions? We will use our understanding of counting particles and chemical reactions as our “recipe” for how atoms are rearranged. These rearrangements allow us to quantitatively predict the amount of any chemical species within chemical reactions.

Stage 1: Learning Goals

Established Goals	Transfer			
Standards	Long-Term Transfer Goals			
Pennsylvania Academic Standards Science (2023): 9-12 Standards ■ Use mathematical representations to support the claim that atoms, and therefore mass, are conserved during a chemical reaction. Clarifying 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	What kinds of long-term, independent accomplishments are desired? Students will be able to independently use their learning to... ■ Approach science as a reliable and testable way of knowing and explaining the natural world and designed world. (Life-Long Learner) (T1) ■ Weigh evidence and use scientific approaches to ask questions, investigate, and make informed decisions. (Innovative Problem Solver) (T2) ■ Make and use observations to analyze relationships and patterns in order to explain phenomena, develop models, and make predictions. (Communicator) (T3) ■ Participate in respectful discourse with peers, teachers, and experts in the field to share ideas, perspectives, and findings. (Collaborator, Communicator) (T4)			
	Meaning			
	<table> <tr> <th>Understandings</th><th>Essential Questions</th></tr> <tr> <td> What specifically do you want students to understand? What inferences should they make? Students will understand that... ■ Stoichiometry uses mole ratios from balanced chemical equations to </td><td> What thought-provoking questions will foster inquiry, meaning making, and transfer? Students will keep considering... ■ How can stoichiometry be used to determine the amount of reactants and </td></tr> </table>	Understandings	Essential Questions	What specifically do you want students to understand? What inferences should they make? Students will understand that... ■ Stoichiometry uses mole ratios from balanced chemical equations to
Understandings	Essential Questions			
What specifically do you want students to understand? What inferences should they make? Students will understand that... ■ Stoichiometry uses mole ratios from balanced chemical equations to	What thought-provoking questions will foster inquiry, meaning making, and transfer? Students will keep considering... ■ How can stoichiometry be used to determine the amount of reactants and			

thinking and not on memorization and rote application of problem-solving techniques.

Assessment Boundary: Assessment does not include complex chemical reactions. (3.2.9-12.G)

Profile of a CV Learner

- Collaboration: Students will be able to independently engage and meaningfully contribute to a team to reach a common goal, through mutual reflection, feedback, and shared responsibility. (PCVL.CO)
- Communication: Students will be able to independently and confidently adapt their writing and speaking in relation to audience, task, and purpose, as well as practice active listening to understand other perspectives, viewpoints, and cultures. (PCVL.CM)
- Innovative Problem Solving: Students will be able to independently use their learning to approach new problems with curiosity and creativity while consistently seeking growth through self-reflection and a willingness to accept constructive feedback. (PCVL.IPS)
- Life-Long Learner: Students will be able to independently use their learning to analyze past and ongoing performance, adjust thinking processes to new contexts, and use information to make informed and conscientious decisions. (PCVL.LLL)

mathematically determine the amount any chemical species involved in the given chemical reaction. (U1)

- Teams work efficiently and effectively when members share leadership and decision-making responsibilities. (U2)
- Innovative problem-solvers realize that failure is an opportunity to learn and accept constructive feedback to evaluate and revise their thinking. (U3)
- We recognize that getting stuck is a natural progression in learning and use setbacks to identify new strategies and improve this process. (U4)
- Writing reports for scientific experiments allow us to effectively communicate our results with any audience. (U5)

products involved in chemical reactions? (Q1)

- What makes a group effective? How are we working together right now? How can we continue to improve to meet a common goal? (Q2)
- How do I come up with a solution that can potentially help with this problem? (Q3)
- What am I doing when I get stuck? What are some strategies I can try? How are they working? (Q4)
- How can we use writing to communicate the results of our scientific experiments? (Q5)

Acquisition of Knowledge & Skill

Knowledge

What facts and basic concepts should students know and be able to recall?
Students will know...

- That balanced chemical reactions follow the Law of Conservation of Mass. (K1)
- That mole ratios are shown as the coefficients in balanced chemical equations. (K2)
- The difference between actual yield, theoretical yield, and percent yield. (K3)
- That limiting reactants are consumed first during the chemical reaction. (K4)

Skills

What discrete skills and processes should students be able to use? Students can...

- I can determine the mass of any chemical species, given the balanced equation and mass of participating chemical species. (S1)
- I can calculate the percent yield for chemical reactions given experimental data. (S2)
- I can determine which reactant limits the formation of products in chemical reactions. (S3)

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| | | <ul style="list-style-type: none">■ I can use stoichiometry with experimental data to predict the balanced chemical equation for an unknown chemical reaction. (S4) |
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Unit 5 - Kinetics & Equilibrium

Draft Date	Course	Duration	Grades	Subjects	Team
07-28-2026	HS H/CP/GEN Chemistry	3 Week(s)	10, 11, 12	Science	Adam Miller, Matthew Fox, Dylan Tull, Ashley Johnston, Adam Miller
Focus					
Have you ever seen rust form on metal surfaces? Chemical reactions take different amounts of time to reach equilibrium. We will use our current understanding of chemical reactions to investigate what affects the rate of chemical reactions and how chemical species interact as reactions near equilibrium.					
Stage 1: Learning Goals					
Established Goals		Transfer			
Standards		Long-Term Transfer Goals			
Pennsylvania Academic Standards Science (2023): 9-12 Standards ■ 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. Clarifying Statement: Emphasis is on student reasoning that focuses on the number and energy of collisions between molecules. Assessment Boundary: Assessment is limited to simple reactions in which there are only two reactants; evidence from		What kinds of long-term, independent accomplishments are desired? Students will be able to independently use their learning to... ■ Approach science as a reliable and testable way of knowing and explaining the natural world and designed world. (Life-Long Learner) (T1) ■ Weigh evidence and use scientific approaches to ask questions, investigate, and make informed decisions. (Innovative Problem Solver) (T2) ■ Make and use observations to analyze relationships and patterns in order to explain phenomena, develop models, and make predictions. (Communicator) (T3) ■ Participate in respectful discourse with peers, teachers, and experts in the field to share ideas, perspectives, and findings. (Collaborator, Communicator) (T4)			
		Meaning			
		Understandings			
		What specifically do you want students to understand? What inferences should they make? Students will understand that... ■ Increased concentration and temperature will often increase the			

temperature, concentration, and rate data; and qualitative relationships between rate and temperature. (3.2.9-12.E)

- Refine the design of a chemical system by specifying a change in conditions that would produce increased amounts of products at equilibrium.

Clarifying Statement: Emphasis is on the application of Le Chatelier'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.

Assessment Boundary: Assessment is limited to specifying the change in only one variable at a time. Assessment does not include calculating equilibrium constants and concentrations. (3.2.9-12.F)

Profile of a CV Learner

- Collaboration: Students will be able to independently engage and meaningfully contribute to a team to reach a common goal, through mutual reflection, feedback, and shared responsibility. (PCVL.CO)
- Innovative Problem Solving: Students will be able to independently use their learning to approach new problems with curiosity and creativity while consistently seeking growth through self-reflection and a

speed of chemical reactions based on collision theory. (U1)

- Chemical reactions at equilibrium will shift to counteract changes to that system to establish equilibrium once again. (U2)
- Teams work efficiently and effectively when members share leadership and decision-making responsibilities. (U3)
- Innovative problem-solvers realize that failure is an opportunity to learn and accept constructive feedback to evaluate and revise their thinking. (U4)

Essential Questions

What thought-provoking questions will foster inquiry, meaning making, and transfer? Students will keep considering...

- How does changing the temperature or concentration of particles affect the speed of reaction completion? (Q1)
- How can chemical reactions be altered to increase the amount of products formed at equilibrium? (Q2)
- What makes a group effective? How are we working together right now? How can we continue to improve to meet a common goal? (Q3)
- How can we approach learning even when our first attempt was not successful? (Q4)

Acquisition of Knowledge & Skill

Knowledge

What facts and basic concepts should students know and be able to recall? Students will know...

- That concentration of a solution describes the amount of solute present in a given volume of solution. (K1)
- The criteria for successful chemical reactions. (K2)
- That reaction rates are usually dependent on the concentration of reactants. (K3)
- That chemical reactions reach equilibrium when the forward reaction

Skills

What discrete skills and processes should students be able to use? Students can...

- I can calculate the concentration of substances given the number of moles dissolved in the given sample of water. (S1)
- I can use the method of initial rates to determine the rate law for chemical reactions, given experimental data. (S2)
- I can apply Le Chatelier's Principle to explain changes to chemical systems at equilibrium. (S3)

willingness to accept constructive feedback. (*PCVL.IPS*)

rate is equivalent to the reverse reaction rate. (*K4*)