acids and bases pogil

acids and bases pogil offer a structured, inquiry-based approach to understanding fundamental chemical concepts. This article delves into the core principles of acids and bases, exploring their definitions, properties, reactions, and the quantitative measurements used to describe them. We will navigate through the Brønsted-Lowry and Arrhenius theories, discuss the significance of pH and pOH, and examine the behavior of strong and weak acids and bases. Understanding these concepts is crucial for various scientific disciplines, and the POGIL method, with its emphasis on active learning and collaborative problem-solving, provides an effective pathway to mastery. Prepare to explore the fascinating world of acidic and basic solutions and how they interact in chemical systems.

Understanding Acids and Bases: A POGIL Approach

The study of acids and bases is a cornerstone of chemistry, impacting everything from biological processes to industrial applications. Traditional lecture-based methods can sometimes leave students with rote memorization rather than genuine comprehension. The POGIL (Process Oriented Guided Inquiry Learning) methodology, however, transforms this by engaging students in hands-on exploration and discovery. This approach fosters deeper understanding and critical thinking skills essential for grasping the nuances of acidic and basic substances. We will explore the foundational definitions and characteristics that distinguish these two vital classes of chemical compounds.

Key Definitions of Acids and Bases

At the heart of understanding acids and bases lies a clear grasp of their definitions. Over time, chemical understanding has evolved, leading to several prominent theories that describe their behavior. Each theory offers a unique perspective, building upon previous knowledge to provide a more comprehensive picture of acidic and basic properties.

The Arrhenius Theory of Acids and Bases

The Arrhenius theory, one of the earliest attempts to define acids and bases, focuses on the behavior of substances in aqueous solutions. According to Arrhenius, an acid is a compound that increases the concentration of hydrogen ions (H^+) when dissolved in water. Conversely, a base is a compound that increases the concentration of hydroxide ions (OH^-) in an aqueous solution. While influential, the Arrhenius theory is limited in its scope, primarily addressing substances that contain hydrogen or hydroxide groups and are soluble in water.

The Brønsted-Lowry Theory of Acids and Bases

The Brønsted-Lowry theory offers a broader definition, moving beyond aqueous solutions. A Brønsted-Lowry acid is defined as a proton (H^+) donor, while a Brønsted-Lowry base is a proton acceptor. This definition introduces the concept of conjugate acid-base pairs. When an acid donates a proton, it becomes a conjugate base, and when a base accepts a proton, it becomes a conjugate acid. This theory is more versatile, explaining acid-base reactions in a wider range of solvents and even in the

gas phase.

Lewis Acids and Bases

The most general definition comes from the Lewis theory. A Lewis acid is an electron-pair acceptor, and a Lewis base is an electron-pair donor. This theory encompasses reactions that do not involve proton transfer, such as the formation of coordinate covalent bonds. Lewis acid-base theory is particularly useful in understanding reactions involving metal ions and organic chemistry transformations.

Properties of Acids and Bases

Acids and bases exhibit distinct physical and chemical properties that allow for their identification and differentiation. These properties are a direct consequence of their molecular structures and their interactions with other substances.

Physical Properties of Acids

Many common acids are colorless liquids or solids. They often have a sour taste, although tasting chemicals is strongly discouraged in laboratory settings. Acids can also be corrosive, meaning they can damage materials and living tissue. Some common examples include citric acid found in lemons and acetic acid in vinegar.

Physical Properties of Bases

Bases, often referred to as alkalis when dissolved in water, are typically bitter and feel slippery or soapy to the touch. Like acids, many bases are corrosive. Examples include sodium hydroxide, a strong base used in drain cleaners, and ammonia, a common household cleaning agent.

Chemical Properties of Acids

Chemically, acids react with certain metals to produce hydrogen gas. They also react with carbonates and bicarbonates to produce carbon dioxide gas. A characteristic reaction of acids is their neutralization reaction with bases, forming salt and water. Acids also turn blue litmus paper red.

Chemical Properties of Bases

Bases react with acids in neutralization reactions. They can react with certain metals, though less readily than acids. Bases also react with fats and oils, which is why they are effective in soap production and cleaning. Bases turn red litmus paper blue.

Acid-Base Reactions and Neutralization

The interaction between acids and bases is a fundamental chemical process known as neutralization. This reaction is characterized by the combining of acidic and basic properties to produce a neutral solution, typically involving the formation of a salt and water.

The Neutralization Process

In a neutralization reaction, the acidic hydrogen ions (H^+) from an acid react with the hydroxide ions (OH^-) from a base to form water (H_2O). The remaining ions, known as spectator ions, combine to form a salt. For instance, the reaction between hydrochloric acid (HCl) and sodium hydroxide ($NaOH$) produces sodium chloride ($NaCl$) and water (H_2O).

- $HCl(aq) + NaOH(aq) \rightarrow NaCl(aq) + H_2O(l)$

The completeness of neutralization can be monitored using indicators or by measuring the pH of the solution.

Salt Formation

Salts are ionic compounds formed during neutralization reactions. They consist of a cation from the base and an anion from the acid. The properties of a salt depend on the strength of the parent acid and base. Salts formed from strong acids and strong bases are neutral, while those from weak acids and strong bases are basic, and vice versa.

Strength of Acids and Bases

The strength of an acid or base refers to its degree of dissociation or ionization in water. This is a crucial concept for predicting the extent of a reaction and the properties of the resulting solution.

Strong Acids and Bases

Strong acids and bases dissociate completely in water, meaning all or nearly all of their molecules ionize. For example, hydrochloric acid (HCl) and sodium hydroxide ($NaOH$) are considered strong. Their dissociation is represented by a one-way arrow in chemical equations, indicating complete ionization.

- $HCl(aq) \rightarrow H^+(aq) + Cl^-(aq)$
- $NaOH(aq) \rightarrow Na^+(aq) + OH^-(aq)$

Solutions of strong acids and bases have a very low or very high pH, respectively.

Weak Acids and Bases

Weak acids and bases only partially dissociate in water, establishing an equilibrium between the undissociated molecule and its ions. Acetic acid (CH_3COOH) is a common weak acid, and ammonia (NH_3) is a weak base. Their dissociation is represented by equilibrium arrows.

- $CH_3COOH(aq) \rightleftharpoons H^+(aq) + CH_3COO^-(aq)$
- $NH_3(aq) + H_2O(l) \rightleftharpoons NH_4^+(aq) + OH^-(aq)$

The extent of dissociation is quantified by acid dissociation constants (K_a) and base dissociation constants (K_b).

pH and pOH Scales

The pH and pOH scales are quantitative measures used to express the acidity or alkalinity of an aqueous solution. They provide a convenient way to work with very small concentrations of hydrogen and hydroxide ions.

The pH Scale

The pH scale is defined as the negative logarithm (base 10) of the hydrogen ion concentration: $pH = -\log[H^+]$. A pH of 7 is considered neutral at 25°C. Solutions with a pH less than 7 are acidic, and solutions with a pH greater than 7 are alkaline (basic).

The pOH Scale

Similarly, the pOH scale is defined as the negative logarithm (base 10) of the hydroxide ion concentration: $pOH = -\log[OH^-]$. In aqueous solutions at 25°C, the relationship between pH and pOH is given by $pH + pOH = 14$. This relationship allows for easy conversion between the two scales.

Calculating pH and pOH

Calculating pH and pOH involves using the logarithmic definitions and understanding the concentrations of H^+ and OH^- ions. For strong acids and bases, the ion concentration is directly related to the initial concentration of the substance. For weak acids and bases, equilibrium calculations using K_a and K_b values are necessary to determine the ion concentrations and subsequently the pH and pOH.

1. Determine the concentration of H^+ or OH^- ions.
2. Apply the formula $pH = -\log[H^+]$ or $pOH = -\log[OH^-]$.

3. If needed, use the relationship $pH + pOH = 14$ to find the other value.

Applications of Acids and Bases

The understanding of acids and bases is not merely academic; it has profound practical applications across numerous fields.

In Everyday Life

Acids and bases are prevalent in our daily lives. From the digestion of food in our stomachs (hydrochloric acid) to the cleaning products we use (ammonia, sodium hydroxide), their presence is constant. Many foods and beverages derive their characteristic tastes from acidic compounds.

In Industrial Processes

Industries rely heavily on acid-base chemistry. The production of fertilizers, plastics, pharmaceuticals, and dyes often involves acid-base reactions. Sulfuric acid is one of the most widely produced chemicals globally due to its extensive use in various industrial processes, including metal processing and petroleum refining.

In Biological Systems

Biological systems maintain precise pH levels essential for life. Enzymes function optimally within specific pH ranges, and disruptions can lead to severe health consequences. The buffering systems in our blood, for example, regulate pH to prevent drastic changes, showcasing the critical role of acid-base balance.

Frequently Asked Questions

What is the core concept of the POGIL approach when studying acids and bases?

The POGIL approach emphasizes guided inquiry and active learning, where students discover fundamental principles of acids and bases through a series of carefully designed questions and experiments, rather than direct lecture.

How does POGIL typically introduce the Brønsted-Lowry definition of acids and bases?

POGIL often uses visual representations of proton transfer reactions to guide students towards

defining acids as proton donors and bases as proton acceptors, leading to the concept of conjugate acid-base pairs.

What is a common POGIL activity for understanding the concept of pH?

POGIL activities for pH usually involve analyzing numerical data from different solutions and relating it to the concentration of hydrogen ions, leading to the mathematical definition of pH and its logarithmic scale.

How do POGIL materials explain the difference between strong and weak acids/bases?

POGIL likely uses reaction diagrams illustrating complete vs. partial dissociation of acids or bases in water. Students are guided to observe the extent of ionization and its effect on ion concentrations.

What is the significance of 'conjugate pairs' in a POGIL acid-base lesson?

POGIL activities will guide students to identify that when an acid donates a proton, it forms its conjugate base, and when a base accepts a proton, it forms its conjugate acid, highlighting the reversible nature of acid-base reactions.

How does POGIL address the concept of acid-base titration?

POGIL might present titration data (e.g., pH vs. volume of titrant) and prompt students to analyze the equivalence point, half-equivalence point, and the role of indicators in determining the concentration of an unknown acid or base.

What is a POGIL strategy for visualizing the autoionization of water?

POGIL activities often use molecular models or schematic representations of water molecules in equilibrium, showing the formation of hydronium (H_3O^+) and hydroxide (OH^-) ions, leading to the K_w expression.

How does POGIL help students understand buffer solutions?

POGIL likely uses scenarios where small amounts of acid or base are added to solutions containing weak acids and their conjugate bases (or vice versa), prompting students to analyze how these solutions resist pH changes.

What is the role of 'self-reflection' in POGIL acid-base modules?

Many POGIL activities include self-reflection questions that encourage students to articulate their understanding of key concepts, identify areas of confusion, and summarize the learning objectives of

the session.

How does POGIL connect acid-base theory to real-world applications?

POGIL often includes application-based questions at the end of modules, prompting students to relate acid-base concepts to biological systems (e.g., blood pH), environmental issues (e.g., acid rain), or industrial processes.

Additional Resources

Here are 9 book titles related to Acids and Bases POGIL, each with a short description:

1. Investigating Acids and Bases: A POGIL Approach
This workbook guides students through the fundamental concepts of acids and bases using the Process Oriented Guided Inquiry Learning (POGIL) methodology. It focuses on student-driven exploration of acid-base definitions, properties, and reactions. Through hands-on activities and collaborative problem-solving, learners develop a deep understanding of chemical equilibrium and stoichiometry in acid-base contexts.

2. The Chemistry of Acids and Bases: A POGIL Exploration
Designed to foster conceptual understanding, this resource uses guided inquiry to explore the behavior and properties of acids and bases. Students will engage with pH calculations, buffer solutions, and acid-base titrations by working through carefully crafted problems. The POGIL framework encourages critical thinking and peer learning, making complex topics accessible.

3. Acids and Bases: Unlocking the Secrets with POGIL
This book provides a comprehensive yet engaging journey into the world of acids and bases, emphasizing inquiry-based learning. It covers theories like Arrhenius, Brønsted-Lowry, and Lewis, along with their implications in various chemical processes. Learners will build confidence in predicting reaction outcomes and understanding acid-base relationships.

4. POGIL Activities for Acids and Bases: Mastering the Fundamentals
This collection of POGIL-style activities offers a practical and effective way to learn about acids and bases. The exercises are designed to build upon each other, gradually increasing in complexity. Students will actively participate in constructing their knowledge of conjugate pairs, acid dissociation constants, and the concept of neutralization.

5. Conceptual Understanding of Acids and Bases: A POGIL Workbook
This workbook prioritizes conceptual mastery over rote memorization of formulas. It employs the POGIL model to encourage students to discover the relationships between acid strength, concentration, and pH. Through collaborative exploration of equilibrium constants and titration curves, learners gain intuitive insight into acid-base chemistry.

6. The pH Scale and Beyond: A POGIL Journey into Acids and Bases
This resource takes students beyond basic definitions to explore the nuances of the pH scale and its applications. It utilizes POGIL activities to illuminate concepts such as buffers, indicators, and the impact of acids and bases in biological and environmental systems. The inquiry-driven approach ensures that students develop a solid foundation for more advanced chemistry topics.

7. POGIL for General Chemistry: Acids and Bases Edition
This focused edition of POGIL materials specifically targets the acid-base chapter in a typical general chemistry curriculum. It presents a series of student-centered activities designed to guide learners through key concepts like strong and weak acids/bases, hydrolysis, and solubility product. The collaborative nature of POGIL promotes active engagement and shared understanding.

8. Exploring Acid-Base Equilibria: A POGIL Approach
This book delves into the dynamic nature of acid-base reactions by focusing on equilibrium principles. Through guided inquiry, students will analyze factors affecting equilibrium positions, calculate Ka and Kb values, and understand the significance of buffer solutions. The POGIL methodology facilitates a deep understanding of these crucial chemical concepts.

9. Interactive Learning of Acids and Bases: The POGIL Way
This title highlights the interactive and student-centered nature of POGIL for learning about acids and bases. It offers a structured path for students to explore the theories, properties, and reactions of acids and bases through problem-solving and discussion. The book aims to make abstract chemical concepts tangible and understandable through active participation.

Acids And Bases Pogil

Acids and Bases POGIL

Name: Mastering Acids and Bases: A POGIL Approach

Outline:

Introduction: Defining Acids and Bases, Importance of Understanding Acid-Base Chemistry
Chapter 1: Arrhenius Theory: Definition, Strengths and Limitations
Chapter 2: Brønsted-Lowry Theory: Definition, Conjugate Acid-Base Pairs, Strengths and Weaknesses
Chapter 3: Lewis Theory: Definition, Lewis Acids and Bases, Applications
Chapter 4: pH and pOH: Calculation, Significance, and the pH Scale
Chapter 5: Acid-Base Reactions: Neutralization, Titration Curves, Indicators
Chapter 6: Buffers and Buffer Capacity: How Buffers Work, Calculating Buffer pH, Importance in Biological Systems
Chapter 7: Acid-Base Equilibria: Equilibrium Constants (Ka, Kb), Calculating Equilibrium Concentrations
Conclusion: Summary of Key Concepts, Further Applications of Acid-Base Chemistry

Mastering Acids and Bases: A POGIL Approach

Introduction: The Foundation of Acid-Base Chemistry

Understanding acids and bases is fundamental to chemistry and numerous related fields. From the everyday (digestion, cleaning products) to the highly specialized (pharmaceutical development, environmental monitoring), the principles governing acid-base reactions are ubiquitous. This guide utilizes the POGIL (Process Oriented Guided Inquiry Learning) method to actively engage you in learning these critical concepts. We will explore various definitions of acids and bases, delve into their reactions, and examine their significance in diverse contexts. This approach will allow you to construct your understanding rather than passively receiving information, fostering deeper learning and retention.

Chapter 1: Unraveling the Arrhenius Theory

The Arrhenius theory, proposed by Svante Arrhenius in 1884, provides the simplest definition of acids and bases. According to this theory:

Acid: An Arrhenius acid is a substance that increases the concentration of hydrogen ions (H^+) when dissolved in water. Examples include hydrochloric acid (HCl), which dissociates completely into H^+ and Cl^- ions in water, and acetic acid (CH_3COOH), which partially dissociates.
Base: An Arrhenius base is a substance that increases the concentration of hydroxide ions (OH^-) when dissolved in water. Sodium hydroxide (NaOH) is a classic example, readily dissociating into Na^+ and OH^- ions.

Limitations of the Arrhenius Theory: This theory's main limitation is its reliance on aqueous solutions. Many acid-base reactions occur in non-aqueous solvents where the concept of H^+ and OH^- ions is not applicable. This necessitates a broader definition, which is provided by the Brønsted-Lowry theory.

Chapter 2: Expanding the Definition: Brønsted-Lowry Theory

Johannes Nicolaus Brønsted and Thomas Martin Lowry independently proposed a more comprehensive theory in the early 20th century. The Brønsted-Lowry theory defines acids and bases in terms of proton (H^+) transfer:

Acid: A Brønsted-Lowry acid is a proton donor. It donates a proton to a base.
Base: A Brønsted-Lowry base is a proton acceptor. It accepts a proton from an acid.

A crucial concept within this theory is that of conjugate acid-base pairs. When an acid donates a proton, it forms its conjugate base (the species remaining after proton donation). Similarly, when a base accepts a proton, it forms its conjugate acid. For example, in the reaction between HCl (acid) and H_2O (base), H_3O^+ (conjugate acid) and Cl^- (conjugate base) are formed. The strength of an acid is inversely related to the strength of its conjugate base. Strong acids have weak conjugate bases, and weak acids have strong conjugate bases.

Chapter 3: A Broader Perspective: Lewis Theory

Gilbert N. Lewis offered an even more generalized definition of acids and bases, encompassing reactions that don't involve proton transfer. The Lewis theory focuses on electron pairs:

Lewis Acid: A Lewis acid is an electron-pair acceptor. It accepts a pair of electrons from a Lewis base to form a coordinate covalent bond.
Lewis Base: A Lewis base is an electron-pair donor. It donates a pair of electrons to a Lewis acid.

This definition significantly expands the scope of acid-base chemistry. Many metal ions, such as Al^{3+}, act as Lewis acids because they can accept electron pairs. Many molecules with lone pairs of electrons, such as ammonia (NH_3), act as Lewis bases.

Chapter 4: Quantifying Acidity: pH and pOH

The pH scale is a logarithmic scale used to express the acidity or basicity of a solution. It ranges from 0 to 14, with 7 being neutral. A pH less than 7 indicates acidity, while a pH greater than 7 indicates basicity. The pH is defined as:

$$pH = -\log_{10}[H^+]$$

where $[H^+]$ is the concentration of hydrogen ions in moles per liter (M). The pOH scale is similarly defined:

$$pOH = -\log_{10}[OH^-]$$

The relationship between pH and pOH at 25°C is:

$$pH + pOH = 14$$

Understanding pH is crucial in numerous applications, including environmental monitoring, biological systems, and industrial processes.

Chapter 5: Reactions and Titrations: Exploring Acid-Base Interactions

Acid-base reactions are characterized by the transfer of protons (H^+) from an acid to a base. A key reaction is neutralization, where an acid and a base react to form water and a salt. For example:

$$HCl(aq) + NaOH(aq) \rightarrow NaCl(aq) + H_2O(l)$$

Titration is a quantitative technique used to determine the concentration of an unknown acid or base solution using a solution of known concentration. Titration curves, graphs of pH versus volume of titrant added, provide valuable information about the strength of the acid or base being titrated. Indicators are substances that change color at a specific pH range, signaling the endpoint of a titration.

Chapter 6: Maintaining Stability: Buffers and Buffer Capacity

A buffer is a solution that resists changes in pH upon the addition of small amounts of acid or base. Buffers are typically composed of a weak acid and its conjugate base (or a weak base and its

conjugate acid). The Henderson-Hasselbalch equation is used to calculate the pH of a buffer solution:

$pH = pKa + \log_{10}([A^-]/[HA])$

where pKa is the negative logarithm of the acid dissociation constant (Ka), $[A^-]$ is the concentration of the conjugate base, and [HA] is the concentration of the weak acid. Buffers play crucial roles in biological systems, maintaining the pH of blood and other fluids within a narrow range.

Chapter 7: Equilibrium and Calculations: Understanding Acid-Base Equilibria

Acid-base reactions often reach equilibrium, a state where the rates of the forward and reverse reactions are equal. The acid dissociation constant (Ka) quantifies the extent to which a weak acid dissociates in water. Similarly, the base dissociation constant (Kb) quantifies the extent to which a weak base dissociates. Calculations involving Ka and Kb allow us to determine the equilibrium concentrations of the various species present in a solution. These calculations often involve the use of the ICE (Initial, Change, Equilibrium) table.

Conclusion: The Broad Reach of Acid-Base Chemistry

This exploration of acids and bases using a POGIL approach has provided a comprehensive overview of fundamental concepts and their applications. From Arrhenius to Lewis theories, we've seen the evolution of definitions and the broadening of our understanding. The ability to calculate pH, understand buffer systems, and interpret titration curves are crucial skills for anyone working in chemistry or related fields. This knowledge serves as a foundation for further studies in areas such as organic chemistry, biochemistry, and environmental science.

FAQs:

1. What is the difference between a strong acid and a weak acid? A strong acid completely dissociates in water, while a weak acid only partially dissociates.
2. What is a neutralization reaction? A neutralization reaction is a reaction between an acid and a base that produces water and a salt.
3. How does a buffer solution work? A buffer solution resists changes in pH by containing a weak acid and its conjugate base (or a weak base and its conjugate acid).
4. What is the Henderson-Hasselbalch equation used for? It's used to calculate the pH of a buffer solution.
5. What is the significance of the pH scale? It provides a quantitative measure of the acidity or basicity of a solution.
6. What are conjugate acid-base pairs? They are an acid and a base that differ by a single proton (H^+).
7. What is the difference between Arrhenius, Brønsted-Lowry, and Lewis definitions of acids and bases? They represent increasing levels of generality in defining acids and bases.
8. What is titration, and why is it important? Titration is a technique used to determine the concentration of an unknown solution; it's crucial for quantitative analysis.
9. How do acid-base indicators work? They change color within a specific pH range, indicating the endpoint of a titration or a specific pH.

Related Articles:

1. Acid-Base Titration Calculations: A detailed guide on performing calculations related to acid-base titrations.
2. Understanding Acid-Base Equilibria: A deeper dive into equilibrium constants and calculations.
3. Buffer Solutions and Their Applications: Exploring the diverse applications of buffer solutions in various fields.
4. pH Measurement Techniques: A review of different methods for measuring pH.
5. Acid-Base Reactions in Biological Systems: The role of acid-base chemistry in biological processes.
6. Strong Acids and Bases: Properties and Reactions: Detailed study of strong acids and bases.
7. Weak Acids and Bases: Properties and Calculations: Focus on weak acids and bases, including calculations.
8. Lewis Acid-Base Theory and Applications: An in-depth exploration of the Lewis theory.
9. Acid Rain and its Environmental Impact: Examining the effects of acid rain on the environment.

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acids and bases pogil: POGIL Shawn R. Simonson, 2023-07-03 Process Oriented Guided Inquiry Learning (POGIL) is a pedagogy that is based on research on how people learn and has been shown to lead to better student outcomes in many contexts and in a variety of academic disciplines. Beyond facilitating students' mastery of a discipline, it promotes vital educational outcomes such as communication skills and critical thinking. Its active international community of practitioners provides accessible educational development and support for anyone developing related courses.Having started as a process developed by a group of chemistry professors focused on helping their students better grasp the concepts of general chemistry, The POGIL Project has grown into a dynamic organization of committed instructors who help each other transform classrooms and improve student success, develop curricular materials to assist this process, conduct research expanding what is known about learning and teaching, and provide professional development and collegiality from elementary teachers to college professors. As a pedagogy it has been shown to be effective in a variety of content areas and at different educational levels. This is an introduction to the process and the community.Every POGIL classroom is different and is a reflection of the uniqueness of the particular context – the institution, department, physical space, student body, and instructor – but follows a common structure in which students work cooperatively in self-managed small groups of three or four. The group work is focused on activities that are carefully designed and scaffolded to enable students to develop important concepts or to deepen and refine their understanding of those ideas or concepts for themselves, based entirely on data provided in class, not on prior reading of the textbook or other introduction to the topic. The learning environment is structured to support the development of process skills –– such as teamwork, effective communication, information processing, problem solving, and critical thinking. The instructor's role is to facilitate the development of student concepts and process skills, not to simply deliver content to the students. The first part of this book introduces the theoretical and philosophical foundations of POGIL pedagogy and summarizes the literature demonstrating its efficacy. The second part of the book focusses on implementing POGIL, covering the formation and effective management of student teams, offering guidance on the selection and writing of POGIL activities, as well as on facilitation, teaching large classes, and assessment. The book concludes with examples of implementation in STEM and non-STEM disciplines as well as guidance on how to get started. Appendices provide additional resources and information about The POGIL Project.

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the body. It does so through the process of passive diffusion. Effective diffusion is accomplished by intricate parallel structures of airways and blood vessels designed to bring ventilation and perfusion together in an appropriate ratio in the same place and at the same time. Gas exchange is determined by the ventilation-perfusion ratio in each of the gas exchange units of the lung. In the normal lung ventilation and perfusion are well matched, and the ventilation-perfusion ratio is remarkably uniform among lung units, such that the partial pressure of oxygen in the blood leaving the pulmonary capillaries is less than 10 Torr lower than that in the alveolar space. In disease, the disruption to ventilation-perfusion matching and to diffusional transport may result in inefficient gas exchange and arterial hypoxemia. This volume covers the basics of pulmonary gas exchange, providing a central understanding of the processes involved, the interactions between the components upon which gas exchange depends, and basic equations of the process.

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empirical educational research findings that inform STEM pedagogy. You'll also find a new section on actively engaging students in synchronous and asynchronous online courses, and content has been substantially revised to reflect recent developments in instructional technology and online course development and delivery. Plan and deliver lessons that actively engage students—in person or online Assess students' progress and help ensure retention of all concepts learned Help students develop skills in problem-solving, self-directed learning, critical thinking, teamwork, and communication Meet the learning needs of STEM students with diverse backgrounds and identities The strategies presented in Teaching and Learning STEM don't require revolutionary time-intensive changes in your teaching, but rather a gradual integration of traditional and new methods. The result will be a marked improvement in your teaching and your students' learning.

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time to refer to or are not readily available to them. In response, this book offers an essential and easily accessible guide.

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