2025 Electronic Book (E-Book) of Association of Science Educators Anambra (ASEA)
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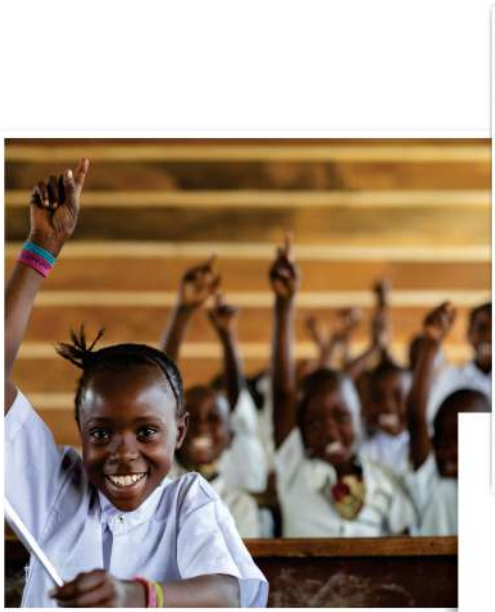
INNOVATIVE STRATEGIES FOR TEACHING VOCATIONAL, SCIENCE, TECHNOLOGY AND MATHEMATICS EDUCATION: CLASSROOM PRACTICES



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A publication of Association of Science Educators Anambra (ASEA)

Printed in Nigeria in the year 2025 by:
Love Isaac Consultancy Services
No 1 Etolue Street, Ifite Awka, Anambra State, Nigeria
+234-803-549-6787, +234-803-757-7391

ISBN: 978-978-695-938-2

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PREFACE

The electronic book (e-book) acknowledges that traditional methods in Vocational, Science, Technology and Mathematics Education: Classroom Practices may not be sufficient to equip students with the necessary skills for a rapidly evolving technological landscape.

Therefore, it advocates for the adoption of Innovative teaching approaches that promote a more dynamic and effective learning experience.

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FOREWORD

This book entitled "**Innovative Strategies for Teaching Vocational, Science, Technology and Mathematics Education: Classroom Practices",** is a book of readings on various innovative classroom pedagogies. It is a welcome literature for Education System and a very important resource book for teachers who are functioning in the disciplines of Vocational Education, Science, Mathematics and Technology education and training. It is a compendium of most of the **active learning strategies** aimed at producing graduates who have been prepared for adaptation to the conditions of the 21st century world of fluidity. The 21st century world accommodates soft skills which the individual can edit from time to time as the conditions of socio-cultural, economic and technological environments change constantly and uncontrollably. A century in which cross-border job openings are important means of employment, a century where attitude is more important than subject-based excellence, a century where collaboration, innovation and creativity are irreducible demands by employers of labour, a century where adaptive skills are critical for entrepreneurship, creation of jobs and wealth.

All categories of teachers at all levels of education would find this resource book interesting and professionally helpful for their teaching practice. Because conditions of the modern world are in perpetual flux, teachers have to re-skill in order to produce adaptive graduates and the era of lecture method is literally over. It is these modern innovative instructional strategies that would enable teachers to produce such graduates who would survive and then succeed in the 21st century global economy.

This book would also be very useful to researchers and innovators in the envisioned pedagogic paradigm shift of this era. I therefore, proudly recommend this book, a compendium on innovative pedagogies to all classes of teachers and researchers on pedagogies and curriculum reforms in the modern era.

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DEDICATION

This book is dedicated to educators in the world

CHAPTER 15

BUILDING A STRONG FOUNDATION IN CHEMISTRY FOR BEGINNERS

Obikezie Maxwell Chukwnazo

Abstract

This chapter in a book provides a comprehensive guide for Chemistry beginners, illuminating the fundamental concepts necessary for building a solid understanding of the subject. The book systematically explores the building blocks of matter, starting with an in-depth examination of atoms, atomic structure, and the formation of molecules. It demystifies the periodic table, presenting it as a roadmap that reveals the relationships between elements and their properties, guiding students to predict reactivity and understand periodic trends. The language of chemical bonds is then unpacked, focusing on how molecules and compounds are formed and named, emphasizing the role of chemical formulas and nomenclature. The nature of chemical bonds – ionic, covalent, and intermolecular forces is thoroughly explained, detailing how these interactions dictate the physical and chemical properties of matter. Finally, the book culminates with practical strategies for building a strong foundation in Chemistry, encouraging active engagement with the material, emphasizing conceptual understanding over rote memorization, and providing guidance on effective problem-solving techniques. This chapter book serves as an invaluable resource for students embarking on their Chemistry journey, empowering them to confidently explore and master this fascinating scientific discipline.

Keywords: Strong Foundation, Chemistry for Beginners

Introduction

Beginners often struggle with Chemistry because its concepts are abstract and invisible to the naked eye. Understanding atoms, molecules, and reactions requires imagining processes beyond direct sensory experience, which can be challenging. This complexity makes Chemistry seem intimidating initially, but with patience and practice, concepts become clearer and more tangible over time.

However, practical down-to-earth approach to teaching Chemistry is crucial for fostering student understanding and interest, especially given the abstract nature of many concepts. Using models, visual aids, and contextualized instructional materials helps bridge the gap between theoretical principles and real-world experiences (Rocard et al., 2007). For instance, molecular models can visually demonstrate the structure of compounds, making invisible atomic arrangements tangible to learners (Hofstein & Lunetta, 2004). Additionally, integrating everyday examples such as using kitchen Chemistry to explain acids and bases makes abstract ideas more relatable, increasing motivation and comprehension (Akpan, Ibeneme & Eke, 2021).

Employing diverse pedagogical strategies, like cooperative learning, inquiry-based experiments, and technology-enhanced visualization tools, caters to different learning styles and enhances engagement (Bell, Trundle & Smetana, 2020). Demonstrations, for instance, with common household substances, allow students to observe chemical changes firsthand, fostering experiential learning. Digital simulations and animations can illustrate microscopic processes, addressing the challenge of visualizing phenomena too small to see with the naked eye (Minner, Levy & Century, 2016). These methods help demystify complex concepts, making learning more interactive and enjoyable.

Incorporating these strategies aligns with contemporary educational theories emphasizing active, learner-centered approaches that build meaningful understanding through context and experience (Duit & Treagust, 2012). Such approaches make Chemistry teaching more accessible and

stimulating, encouraging students to explore the subject deeply and positively affect their attitudes toward science. One can ask as a beginner, what is this Chemistry?

Chemistry is the scientific study of matter, its properties, composition, structure, and the changes it undergoes during chemical reactions. It is often referred to as the central science because it connects physics with various other natural sciences, such as biology, geology, and environmental science (Mandal, Das, & Gupta, 2025). Chemistry encompasses a wide range of sub-disciplines, including organic Chemistry, which focuses on carbon-containing compounds; inorganic Chemistry, which deals with minerals and metals; analytical Chemistry, involving the analysis of substances; and physical Chemistry, which combines physics and Chemistry principles to study chemical systems (Mandal et al., 2025; Yin, Zhang, Jiang, Wang, Li, Xu & Tan, 2025).

Fundamentally, Chemistry explores how substances interact, combine, and transform, which is essential for understanding processes in both the natural world and industrial applications. Through chemical reactions, new substances with distinct properties can be formed, enabling advancements in pharmaceuticals, materials science, and energy solutions. The discipline relies on a systematic approach, utilizing the scientific method to formulate hypotheses, conduct experiments, and analyze results (Verma, Sharma, Chayawan, Dubey, & Kundan, 2025).

Statement of the Problem

Chemistry as an important subject to humanity explores how substances interact, combine, and transform, which is essential for understanding processes in both the natural world and industrial applications. It provides a solid understanding of fundamental principles which are essential for success in chemistry and other STEM fields. This foundation helps learners develop a better grasp of how the world around them works and prepares them for more advanced studies and future careers.

Hence, there is need for beginners' especially secondary school students or high school equivalent to have a strong foundation in the subject. This made the researcher to embark on this study.

Objective of the Study

The primary objective of this study is to establish a solid foundation in chemistry for beginners. This involves introducing fundamental concepts, building confidence in handling chemical principles and fostering an understanding of how chemistry relates to the real world. The goal is to equip students with the necessary skills and knowledge to progress further in their chemistry studies and appreciate its relevance in various fields including technology, medicine and environmental science.

Chemistry the Building Blocks of Matter: Understanding Atoms Atomic Structure and Molecules

In the intricate tapestry of Chemistry, atoms and molecules serve as the fundamental building blocks upon which all matter is constructed. Understanding them is crucial for beginners seeking to navigate the diverse and complex world of chemical science. This section aims to demystify the concept of atom and molecules to provide learners with a clear framework to build their knowledge.

Atoms are the smallest units of matter that retain the properties of an element. Each atom consists of a nucleus, containing protons and neutrons, surrounded by a cloud of electrons that occupy defined energy levels (Pernía et al., 2025).

- **Protons** are positively charged particles found in the nucleus. The number of protons in an atom defines the element; for example, hydrogen has one proton, while carbon has six.
- **Neutrons** are neutral particles that contribute to the mass of an atom but do not affect its charge. The number of neutrons can vary within atoms of the same element, leading to different isotopes.

- **Electrons** are negatively charged particles that orbit the nucleus. They play a vital role in chemical bonding and reactions, as their arrangement determines how an atom interacts with others.

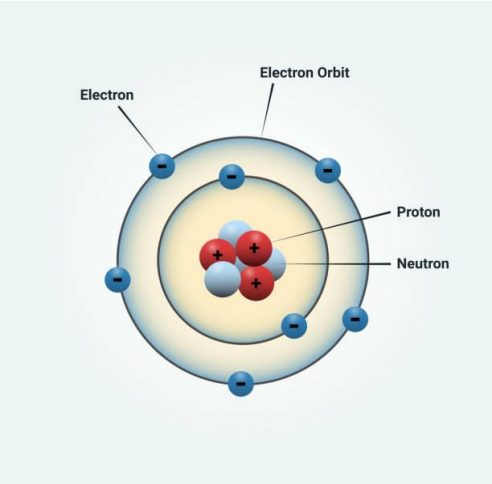

Figure 1: An atom

To visualize an atom as in figure 1, one might imagine a miniature solar system, where the nucleus is like the sun, and the electrons are planets orbiting around it. This analogy can help beginners grasp the concept of atomic structure, though it is essential to understand that electrons exist in probabilistic clouds rather than fixed orbits (Ayyıldız et al., 2022).

However, a molecule is the smallest unit of a chemical substance that retains its properties. It consists of two or more atoms bonded together. Unlike the atoms which are the basic building blocks of matter, and can be of the same element, like oxygen (O_2), or different elements, like water (H_2O), which is made of two hydrogen (H) atoms and one oxygen atom. Molecules are held together by chemical bonds, which can be strong, such as covalent bonds where atoms share electrons, or weaker, like hydrogen bonds (Teixeira-Dias et al., 2005).

Molecules can vary in size and complexity; for example, a simple molecule like carbon dioxide (CO_2) has just three atoms, while proteins and DNA, which are essential for life, can be very large and intricate. Understanding molecules is fundamental in Chemistry as they are involved in every chemical reaction, influencing how substances interact and change (Jegstad., 2023).

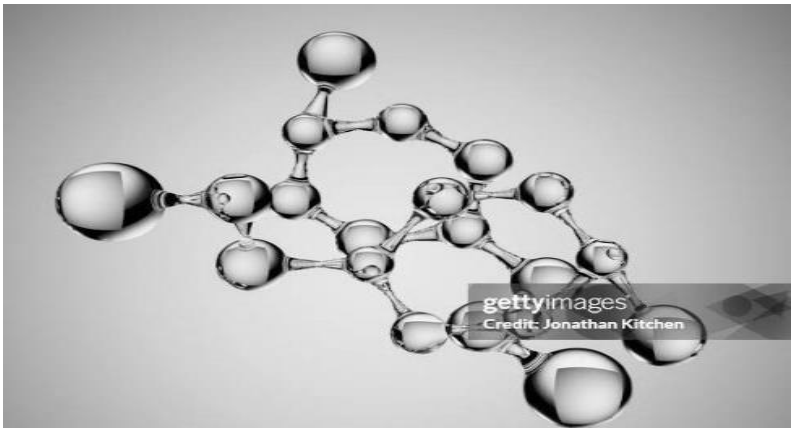

Figure 2: A molecule

From fig. 2, it can be understanding atoms and molecules is crucial in Chemistry, as they govern the composition, structure, and properties of all materials. To grasp these concepts, learners should explore simple experiments, visualize atomic structures, and recognize the significance of

chemical bonds in forming new substances. This foundational knowledge sets the stage for young learners to study chemical reactions and properties in greater depth from identification of elements in periodic table to compounds and complex compounds knowledge (Habashi, 1997).

The Periodic Table: A Roadmap for Elements

The periodic table serves as a foundational roadmap for Chemistry beginners, organizing elements based on their atomic structure and recurring chemical properties. Initially, learners grasp the table's basic layout: horizontal rows (periods) and vertical columns (groups or families) and understand how atomic number increases across a period (Habashi, 1997).

Understanding elemental symbols and atomic masses is crucial. Beginners learn to use the periodic table to predict an element's properties – whether it's a metal, nonmetal, or metalloid – and its reactivity based on its group placement. For example, alkali metals (Group 1) are highly reactive, while noble gases (Group 18) are inert (Pulkkinen, 2020). See figure 3 below

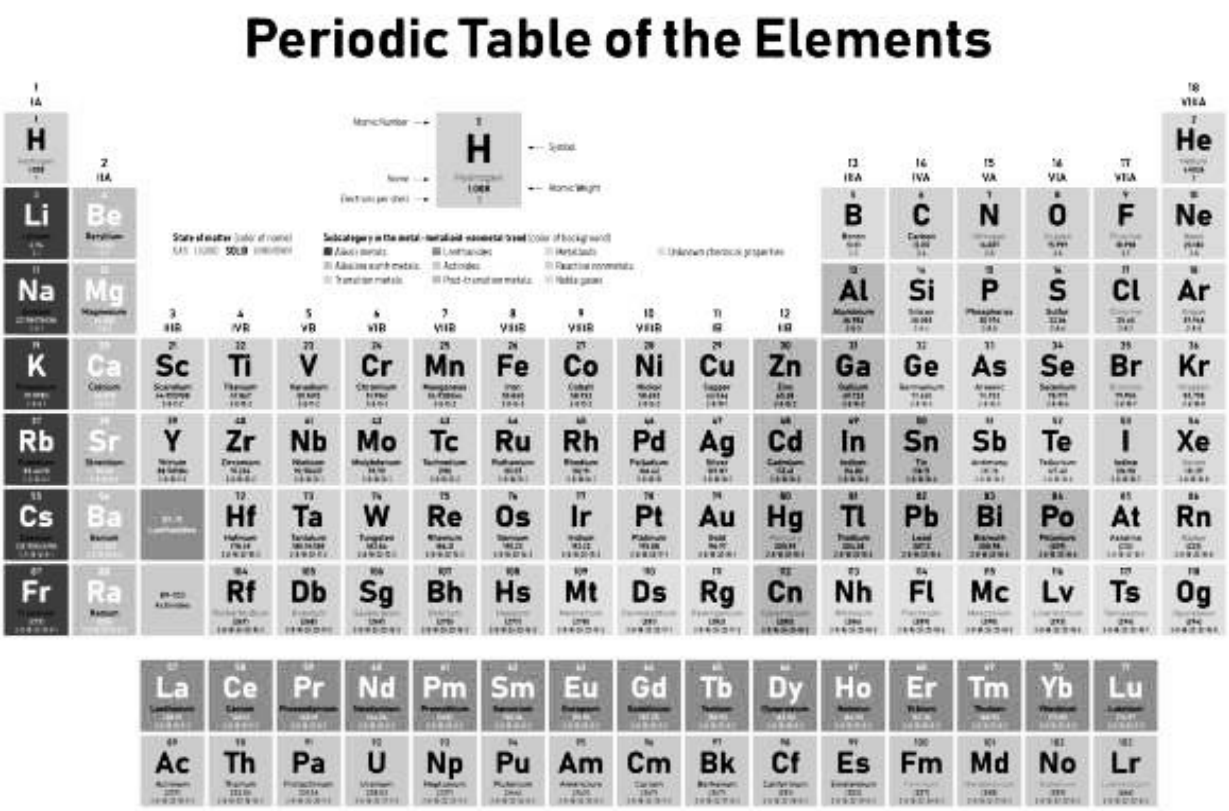

Figure 3: Periodic Table

Electron configuration is linked to the table's structure. Students learn how the number of valence electrons (electrons in the outermost shell) influences an element's bonding behavior. The periodic table visually represents trends in electronegativity, ionization energy, and atomic size, helping students predict how elements will interact and form compounds. By mastering these concepts, beginners gain a solid framework for understanding chemical reactions and the behavior of matter. Also by learning how to read the periodic table, beginners can make connections between elements, identify trends in reactivity, and understand the relationships between different groups of elements, molecules, compounds, metals, nonmetals, and metalloids (Habashi, 1997; Pulkkinen, 2020).

Molecules and Compounds: The Language of Chemical Bonds

For Chemistry beginners, molecules and compounds represent the fundamental vocabulary of chemical bonds. They learn that molecules are formed when two or more atoms are held together by covalent bonds, sharing electrons to achieve stability, while compounds are substances

composed of two or more different elements chemically bonded together – these bonds can be covalent or ionic.
Understanding chemical formulas (like H_2O or NaCl) becomes crucial; these formulas indicate the types and ratios of atoms in a molecule or compound. Students learn to name simple molecules and ionic compounds using IUPAC nomenclature, translating the formulas into understandable names, valence electrons and vice versa (Teixeira-Dias et al., 2005).

The concept of valence electrons plays a key role in understanding how atoms form bonds. Beginners learn to draw lewis structures to visualize electron sharing (covalent bonds) or electron transfer (ionic bonds). They also begin to predict the shapes of simple molecules using some chemical theories, which helps them understand how the arrangement of atoms influences a molecule's properties. By mastering these foundational concepts, students start to read and write the language of chemical bonds, paving the way for understanding chemical reactions and more complex chemical structures (Jegstad, 2023).

Furthermore provided a beginners understand atoms, they can explore how these atoms come together to form molecules. A molecule as earlier asserted is a group of two or more atoms bonded together, which can be of the same or different elements. For instance:

- **Diatomic Molecules:** Elements like O_2 (oxygen) and N_2 (nitrogen) consist of two atoms of the same element.
- **Compounds:** A compound is a type of molecule that contains atoms of two or more different elements, such as H_2O (water) or CO_2 (carbon dioxide).

The Nature of Chemical Bonds

Chemistry beginners learn that chemical bonds are the forces holding atoms together, forming molecules and compounds. They are introduced to the fundamental types: ionic and covalent bonds. Ionic bonds arise from the electrostatic attraction between oppositely charged ions formed through electron transfer, typically between a metal and a nonmetal. Students understand that this transfer leads to the formation of stable, charged ions, resulting in a crystal lattice structure. For example ionic bonds which occur when one atom donates an electron to another, resulting in positively and negatively charged ions that attract each other (Bag et al., 2021).

Covalent bonds, on the other hand, involve the sharing of electrons between atoms, usually nonmetals, to achieve a stable electron configuration. Beginners learn about single, double, and triple bonds, understanding that more shared electrons result in stronger and shorter bonds. They also explore the concept of electronegativity, learning how differences in electronegativity between bonded atoms lead to polar covalent bonds, where electrons are unequally shared, creating partial charges. More so, covalent bonds involve the sharing of electrons between atoms, creating a more stable arrangement (Bag et al., 2021; Yin et al., 2025).

Furthermore, beginners are introduced to intermolecular forces like hydrogen bonding, dipole-dipole interactions, and London dispersion forces, understanding how these weaker forces influence the physical properties of substances, such as boiling point and melting point. Comprehending the nature of chemical bonds lays the groundwork for understanding chemical reactions and the properties of matter. Understanding these bonds lays the foundation which helps to build a strong foundation in Chemistry by grasping more complex reactions and the principles of chemical interactions.

Building a Strong Foundation in Chemistry

To build a strong foundation in Chemistry, beginners should prioritize a systematic and conceptual approach to learning. Start with the fundamentals: understanding atomic structure, the periodic table, and basic chemical nomenclature. Don't rush through these early topics, as they underpin everything else (Atwood, 2024).
Actively engage with the material. Don't just passively read textbooks; work through practice problems, draw some diagrams like atom, molecule just as shown above, and explain concepts in

your own words. Utilize online resources, videos, and interactive simulations to visualize abstract ideas like molecular structure and bonding.
Focus on understanding why concepts work, not just memorizing facts. For example, instead of memorizing periodic table as shown above, understand how they relate to electron configuration and nuclear charge. Connect new information to what you already know to create a cohesive understanding (Obikezie et al., 2023).
Practice consistently. Chemistry requires problem-solving skills, so regularly work through a variety of problems, starting with simple ones and gradually increasing complexity. Seek help when you are stuck; don't let misunderstandings linger (Atwood, 2024).
Form study groups and collaborate with peers. Explaining concepts to others reinforces your understanding and exposes you to different perspectives. Finally, cultivate a genuine curiosity about the subject. Chemistry is all around us, so try to connect what you're learning to real-world applications and phenomena. This will make the learning process more engaging and meaningful (Bulpitt, 2008; Obikezie, Ezeliorah & Okafor., 2023).

Conclusion

In conclusion, Chemistry beginners learn by building a layered understanding of core concepts, starting with the atom and progressing to the intricacies of chemical bonds. They first grasp atomic structure, using this knowledge to navigate the periodic table and predict elemental behavior. The periodic table acts as a visual guide, linking atomic composition to macroscopic properties.

Next, students decipher the language of molecules and compounds, learning to represent and name chemical substances. This understanding is then deepened by exploring the nature of chemical bonds – ionic, covalent, and intermolecular forces – which dictate how atoms interact and influence a substance's physical and chemical characteristics.

This progressive approach, from the microcosm of the atom to the interactions between molecules, equips beginners with a solid foundation. By mastering these essential concepts, they gain the ability to interpret the world around them through a chemical lens, paving the way for further exploration of this fascinating field.

Suggestions for Improvement

Base on the x rayed discussions the following suggestion were made;

1. *Teachers should use concrete models and visual aids:* Incorporate physical models, diagrams, and animations to visualize atoms, molecules, and reactions, making abstract concepts meaningful.
2. *Chemistry teachers should relate concepts to real-life contexts:* Connect chemical principles to everyday activities like cooking, cleaning, or medicine to enhance relevance and understanding.
3. *Adopt interactive and inquiry-based learning:* Encourage active participation through experiments, discussions, and problem-solving to foster curiosity and critical thinking.
4. *Chemistry curriculum planers should help to simplify and break down complex topics:* Present information in small, manageable segments and gradually introduce advanced concepts to prevent overwhelming beginners.
5. *Utilization of technology and simulations:* Leverage digital tools and virtual labs to model microscopic processes and experiments safely and engagingly.
6. *Always provide continuous feedback and support:* Offer regular assessments and guidance to monitor progress and build confidence.
7. *Encourage collaborative learning:* Promote peer discussions and teamwork to enhance understanding through shared ideas and experiences.

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