

CHEMISTRY

EXPLAINED



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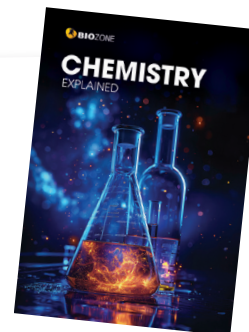
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FAQs ABOUT Chemistry Explained



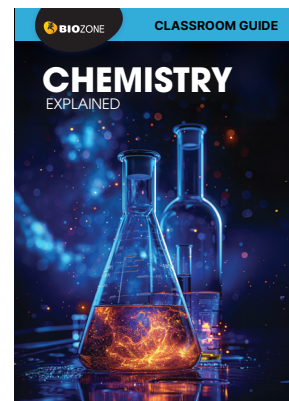
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Using this Classroom Guide

The Classroom Guide comprises the first section of the printed Teacher's Edition. It can also be found in the Teacher Toolkit section of BIOZONE WORLD. The *Chemistry Explained* Classroom Guide is designed to support teachers in getting the most out of BIOZONE's unique worktext approach. It offers insight into the program's key features and serves as a practical reference for planning and delivering lessons, with suggestions for using the activities, embedded features, and resources effectively across print and digital formats. Whether you're new to BIOZONE, teaching the course for the first time, or aiming to streamline your instruction, this guide provides valuable support to help you align the worktext with your curriculum goals.

We encourage teachers to begin by familiarizing themselves with the structure and flow of the worktext, as well as the wide range of supporting resources available within the Teacher Toolkit. Taking time to understand the layout of the chapters, the types of activities included, and the progression of concepts will help you use the worktext as a central resource of your teaching strategy. As you explore the program, refer regularly to this Classroom Guide. It's designed to highlight key features and tools, suggest effective strategies, and provide context for how the different components come together.

We hope you enjoy discovering all that *Chemistry Explained* has to offer.

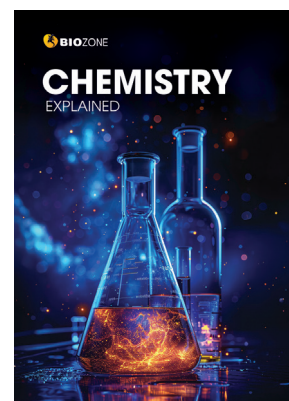


About Chemistry Explained

Chemistry Explained is well-suited for a wide range of learners, from those encountering high school chemistry for the first time, to those preparing for more advanced study. This resource empowers students by making complex ideas approachable, and fostering confidence and curiosity in the subject. Its modular structure, clear conceptual progression, and thoughtfully scaffolded content ensure that students of varying backgrounds and abilities can access content and succeed in chemistry. Foundational topics are introduced and reinforced through targeted support, while engaging visuals and inquiry-based activities promote active learning and a deeper understanding of key chemistry concepts.

Content is presented in logical sections allowing for flexible delivery. In addition to covering foundational material and core chemistry topics, the inclusion of more specialist topics, such as organic and nuclear chemistry, allows teachers to tailor instruction to meet the needs of their curriculum.

Whether you're working in a print, digital, or blended environment, *Chemistry Explained* provides the flexibility and support needed to deliver an engaging and comprehensive chemistry program.



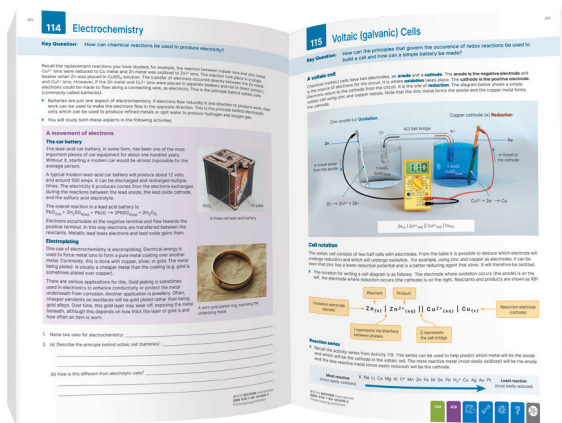
BIOZONE's Pedagogy

A worktext approach

BIOZONE's delivery method is a departure from a traditional textbook. We combine the very best features of a textbook with the utility of a workbook, producing a **worktext** resource. Importantly, the worktext is owned by the student: it is their own resource to utilize. Whether they are using the print or digital version, students customize their worktext with notes and annotations, checking off their progress in the contents and chapter introductions, and input their answers on the pages as they work through the activities.

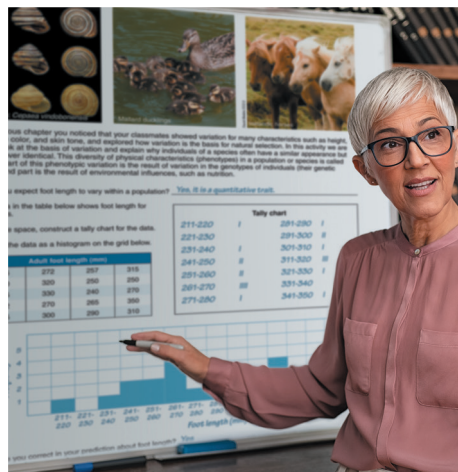
Using a highly graphical approach and short blocks of text, we deliver textbook quality information in an accessible and engaging way, ensuring students are not overwhelmed by large amounts of reading. As students interact with the stimulus material and work through activities, they are encouraged to input their answers directly onto the page. This simple act reinforces the learning moment and forms a **record of work** as they progress through the material. Revision is simplified because the stimulus material, questions, and student answers are in one place.

We have included a wide range of material in *Chemistry Explained*. This includes case studies, data analysis, research activities, practical investigations, and assessment tasks. The variety of activity types provides flexibility in the way teachers can assign them. For example, work can be set as homework, completed in class, or set for revision. Teachers can assign students to work on activities individually or set work as a group. The activity based approach simplifies assigning work and teachers can utilize this to set work for substitute teachers in their absence.



Not all answers need to be graded!

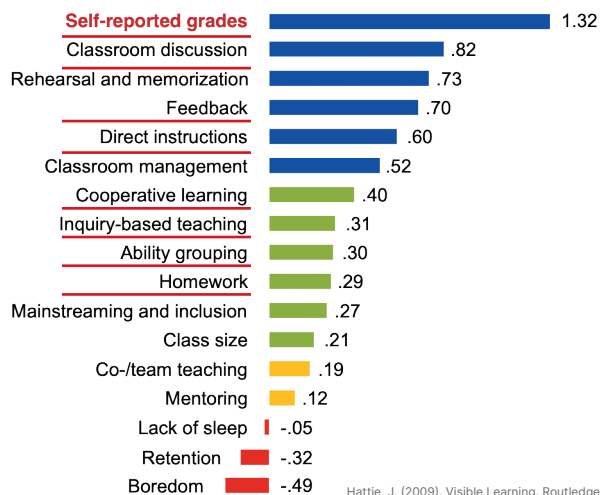
Within the activities, there are plenty of opportunities for students to record answers to the questions in the spaces provided. This approach reinforces the learning moment and allows students to use the resource as a revision tool when they are preparing for assessments. This approach does not mean that teachers are expected to review or grade all student responses. We suggest that only key activities or questions are graded, for example the assessment tasks at the end of each chapter. You may also choose to grade activities with content that students have traditionally found challenging, or where there is often a misunderstanding of the topic. Teachers can also choose to share answers with students. Sharing the model answers via a shared screen allows students to check and self report grades: an exercise known to be a powerful pedagogical learning tool (Hattie, 2009). Having access to model answers also allows students to refine their initial response if needed. This provides a **powerful second learning moment** to consolidate and extend understanding. Teachers can utilize the show/hide model answer feature in the digital platform to share answers.



Features to accelerate student learning

Student learning can be influenced by many factors. A synthesis of more than 1,400 meta studies by Hattie (2009) involving over 80,000 individual studies and 300 million students has revealed some of the major influences to student learning. Some factors negatively influence student learning (red, right) while others have positive effects (yellow, green, and blue, right).

BIOZONE's approach incorporates many of the factors shown to positively influence student learning: these are underlined in red on the diagram (right). By utilizing *Chemistry Explained*, these factors are organically incorporated into content delivery and enhance the teacher and learner experience.



Hattie, J. (2009). Visible Learning. Routledge

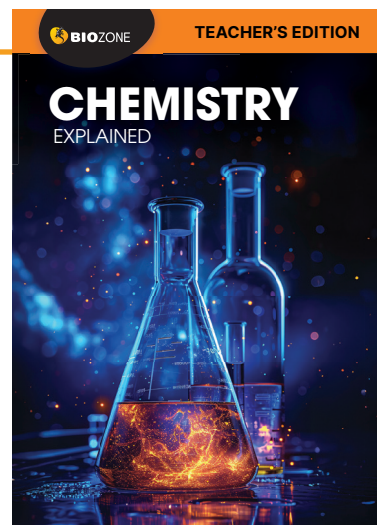
The Teacher Toolkit

The *Chemistry Explained* worktext is supported by the **Teacher Toolkit**, a comprehensive suite of resources designed to support educators to plan, deliver, and assess within their science program. A brief description of the Teacher Toolkit and its components is provided below and on the following pages.

TEACHER'S EDITION

The Teacher's Edition is the teacher's companion to the student worktext and is available in print and digital formats. The material in the Teacher's Edition follows the same flow and order as the Student Edition for easy navigation, but contains additional information and features including:

- Suggested **model answers** in place for each activity.
- A **Classroom Guide** at the beginning of the Teacher's Edition provides an orientation to your BIOZONE resources and is a great resource for getting started. **Teacher notes** provide suggestion for delivery, differentiation, and assessment. The Classroom Guide also provides strategies for teaching in a differentiated classroom, information about the assessment tools, and the benefits of collaborative learning.
- Margin codes (red flags) identify extension material.



TEACHER TOOLKIT

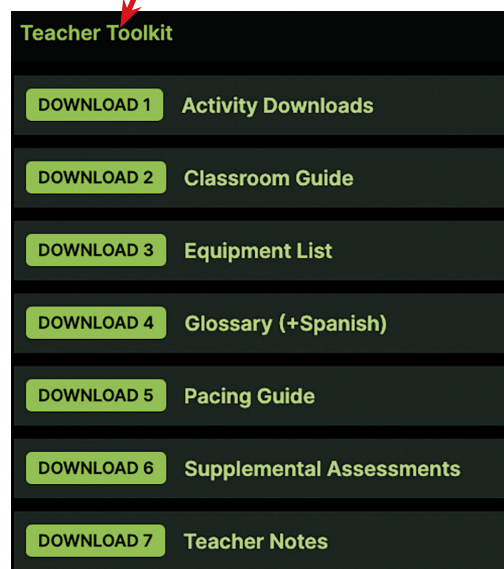
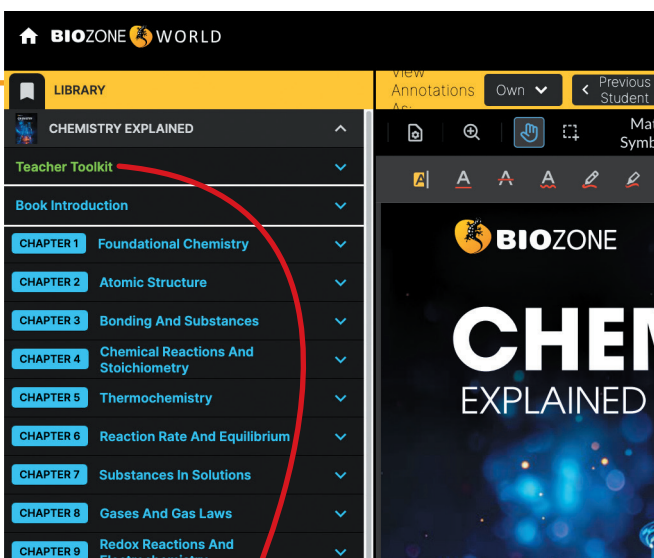
All teachers, whether using the print or digital worktexts with their class, have access to the **Teacher Toolkit**. The Teacher Toolkit is your go-to companion for planning, delivering, and assessing the *Chemistry Explained* content with confidence.

Inside the Teacher Toolkit, you'll find teacher's notes that provide suggestions for scaffolding and differentiation, and highlight key concepts and common misconceptions. Use the pacing guide to help plan delivery, and refer to the digital version of this Classroom Guide as you orient yourself with *Chemistry Explained* and its resources. You'll also have quick access to equipment lists to support planning for practical investigations, and the English/Spanish glossary of key terms supports the development of scientific literacy. When it's time to check students' understanding of the chapter content, download the supplemental assessments, each with suggested marking criteria, for an unseen assessment. Finally, printable answer sheets can be accessed and provided for tasks where students need to be more hands-on (e.g. paper manipulatives, graphing, or drawing tasks).

We encourage you to use these resources to streamline your preparation, instruction, and assessment.

Accessing the Teacher Toolkit:

All teachers, whether using PRINT or DIGITAL materials, access the Teacher Toolkit resources from the Teacher Toolkit section within the BIOZONE WORLD digital platform (right).



BIOZONE WORLD

BIOZONE WORLD, our **science digital platform**, brings together our digital worktexts, Teacher Toolkit, and rich collection of digital resources in a single location for easy access and delivery. Educators can easily plan lessons, assign work, and grade student responses in BIOZONE WORLD.

- ▶ BIOZONE WORLD includes a built-in **translation tool** that supports over 150 languages.
 - ▶ **Student access** to BIOZONE WORLD allows them to access the activities, answer questions online, and submit their work to their teacher. They can use tools to markup, highlight, and bookmark content. Students can directly access an embedded collection of digital resources (presentation slides, 3D models, and curated videos and web links) to support and extend learning.
 - ▶ **Teacher access** to BIOZONE WORLD includes the features available to students plus additional teacher-only features and resources:
 - Managing class enrolments.
 - The ability to view, assign, grade, and give feedback on student work.
 - Forced hand-in feature.
 - A lesson planner supports teachers in structuring activities and assessments to deliver purposeful and well-organized instruction.
 - Access to the Teacher Toolkit (e.g. pacing guides, supplemental assessments, teacher notes and more) to streamline planning, delivery, and assessment.
 - Ability to display the content on a shared screen, ideal for introducing or reviewing an activity, or to highlight information of particular importance (e.g. a key step in a practical investigation).
 - Model answers are in place. Use the show/hide buttons to toggle answers on and off; this is ideal for sharing data or answers with students.
- Students do not have access to model answers on BIOZONE WORLD.*

The screenshot displays the BIOZONE WORLD interface. On the left is a 'LIBRARY' sidebar with a list of activities: Solubility Curves, Molarity, Concentration, And Dilution, Colligative Properties Of Solutions, Defining Acids And Bases (highlighted), Strong And Weak Acids And Bases, Acid And Base Reactions In Water, Conjugate Acids And Bases, PH And Ions, Indicators, PH Calculations - Strong Acids And Bases, Acid-Base Neutralization, and Creating Standard Solutions. The main content area shows a lesson titled '102 Defining Acids and Bases'. It includes a 'Key Question' about the properties and definitions of acids and bases, and two columns of text: 'Properties of acids' and 'Properties of bases'. The 'Properties of acids' section lists characteristics like sour taste and the ability to turn blue litmus paper red. The 'Properties of bases' section lists characteristics like slippery or soapy feel and the ability to neutralize acids. There are also images of lemons and household cleaning products, and a section on 'Preserving food in acid: in a pickle' with an image of pickled vegetables.

Find out more: biozone.com/us/biozone-world

RESOURCE HUB

The BIOZONE **Resource Hub** is available to all students and teachers. It offers a curated collection of Open Educational Resources (OER) specifically chosen to support the content of the worktext. For print users, Resource Hub content is accessed by navigating to a dedicated web page (see next page for details). For digital users, the resources are embedded into BIOZONE WORLD.

The **Resource Hub** is an effective tool to engage students of all abilities within a differentiated classroom. Most resources can be used by students of all abilities. 3D models, videos, games, and simulations are great tools for engaging students in a topic, or supporting striving students in their learning journey.

Some components have been tagged as extension material and can be used to extend capable or gifted students. These types of resources may require more reading or synthesis of information.

Accessing the Resource Hub:

PRINT users: access the **Resource Hub** content through QR codes and links provided in the introductory chapter of the worktext (page ix) and top of next page.

DIGITAL users: the resources are embedded in BIOZONE WORLD and appear automatically in the resource list when an activity is selected

Summary of Resource Hub materials for Chemistry Explained

Resource type	Number of resources*
3D models	50
Videos	268
Weblinks	33
Interactives	96
Downloads	2

* approximate number of resources

Accessing the Resource Hub: Print users

For print only users, the **Resource Hub** is accessed by following the instructions below or by utilizing the bitly tag or QR code (below):

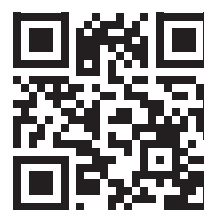
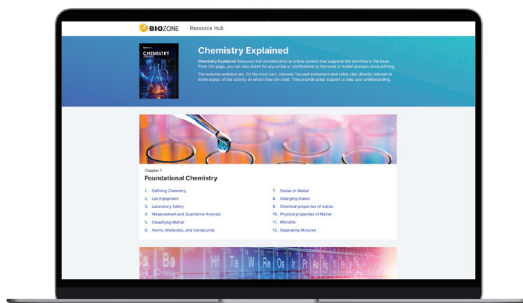
Step 1: Navigate to the BIOZONE **Resource Hub**

www.BIOZONEhub.com

Step 2: Enter this code in the box displayed.

CHEM1-4436

Step 3: Bookmark this page.



bit.ly/3Xkr4xp

Use this bitly tag or QR code to directly access the BIOZONE Resource Hub.

Accessing the Resource Hub: Digital users

For digital users, the **Resource Hub** materials are embedded into the platform and appear automatically when an activity is selected. Digital users also have access to Presentation Slides (see below).

PRESENTATION SLIDES

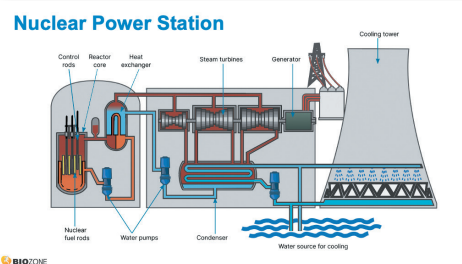
The Presentation Slides are a sizeable collection of slides specifically designed to support and enhance the content of the worktext. They are available to all teachers, and to students with digital access to *Chemistry Explained* on BIOZONE WORLD.

A slide deck is available for each chapter of *Chemistry Explained*, allowing teachers to deliver a lesson in a presentation style format (in class or remotely). Students can use the slides to review content, or teachers may wish to assign them in a flipped class situation where students present the content.

The translation feature enables the content of the Presentation Slides to be translated into 150 languages.

Accessing the Presentation Slides:

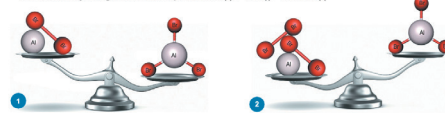
The presentation Slides are embedded into BIOZONE WORLD and automatically appear in the resource list when an activity is selected.



Balancing Equations

The conservation of mass is important in chemistry. Atoms cannot simply disappear during a reaction and reaction equations must account for all of them.

This is done by using a balanced equation: $2\text{Al} + 3\text{Br}_2 \rightarrow 2\text{AlBr}_3$



There is one unit of Al and two units of Br (as Br₂) on the left and one unit of Al and three units of Br on the right.

Br₂ cannot be split to produce singular Br atoms, so the only way to increase the number of Br atoms is to add another Br₂ molecule.

TEACHER NOTES

Teacher's notes (CG30-CG48) can be used as mini lesson plans or as a foundation for building your own, more detailed, lesson plan. Streamline planning by copying and pasting them into your own lesson planner. These notes provide context for the material and additional detail for the learning points. Suggestions for differentiated instruction are provided, including ways to support striving learners and to extend capable students. Where appropriate, opportunities for developing literacy are identified.

Accessing the Teacher Notes:

PRINT and DIGITAL users: Teacher notes are found in the Classroom Guide section of the Teacher's Edition, or can be downloaded from the Teacher Toolkit section of BIOZONE WORLD.

PACING GUIDE

A pacing guide provides suggested delivery times, highlights special notes for consideration, important vocabulary terms, and identifies opportunities for practical activities. Suggestions for formative and summative assessment opportunities are also provided.

Copy and paste this information into your own lesson planning documents to streamline preparation.

Accessing the Pacing Guide:

PRINT and DIGITAL users: Download files from the Teacher Toolkit section of BIOZONE WORLD.

SUPPLEMENTAL ASSESSMENTS

An additional set of assessment tasks are provided as download files for teachers only. Students do not see these tasks prior to you presenting them, so they can be used as formal testing material. They complement the end of chapter assessment tasks found within the worktext. Questions are designed to prompt students to analyze and evaluate information, and synthesize answers. The tasks are suitable to use for formal grading or reporting.

There are two sets of files, student versions (stimulus material and questions only) and teacher versions (with answers and a basic grading rubric provided).

Accessing the Supplemental Assessments:

PRINT and DIGITAL users: Access the files from the Teacher Toolkit section of BIOZONE WORLD.

Supplemental Assessment
Ch 5: Thermochemistry
 Student name: _____ Class: _____

1. (a) On the right is a melting bag of ice. The ice feels cold to the touch. Describe what type of reaction is occurring here, endothermic or exothermic, and provide a reason.

(b) The enthalpy of fusion, $\Delta_{\text{fus}}H^\ominus$, of water = -6.01 kJ/mol . Write this equation:

(c) If the ice bag above contains 4.38 kg of ice, how much water will it melt into water? (Molar mass of H_2O = 18.02 g/mol)

2. (a) Methanol and ethanol are both alcohols and they can be used as fuels, in a similar way to butane. Their combustion reactions can be represented by the following equations:
 Methanol combustion: $\text{CH}_3\text{OH} + \frac{3}{2} \text{O}_2 \rightarrow \text{CO}_2 + 2\text{H}_2\text{O}$, $\Delta_r H^\ominus = -726 \text{ kJ/mol}$
 Ethanol combustion: $\text{C}_2\text{H}_5\text{OH} + 3\text{O}_2 \rightarrow 2\text{CO}_2 + 3\text{H}_2\text{O}$, $\Delta_r H^\ominus = -1367 \text{ kJ/mol}$
 Show with working which fuel, methanol or ethanol, will produce more heat energy when 438 g of each fuel is combusted in excess oxygen (i.e. complete combustion). $\text{MCH}_3\text{OH} = 32.0 \text{ g/mol}$, $\text{MC}_2\text{H}_5\text{OH} = 46.0 \text{ g/mol}$

(b) A group of chemistry students decide to burn methanol in a calorimetry set up to calculate the enthalpy of combustion with their collected data. The students burned 5.22 g of methanol, and the temperature of 1 l of water increased from 21.2°C to 34.2°C . (1 ml = 1 g) $q = m \times c \times \Delta T$, $\Delta H = \frac{q}{n}$, $\Delta H^\ominus = -q/n$
 Using these results, calculate the experimental value of $\Delta_r H^\ominus$ for methanol.
 The specific heat capacity of water is $4.18 \text{ J}^\ominus\text{C}^{-1}\text{g}^{-1}$, $\text{MCH}_3\text{OH} = 32.0 \text{ g/mol}$

(c) Draw and label an enthalpy diagram, modeling the combustion of butane, labelling H_r , H_p , E_a and ΔH^\ominus .

(d) Define activation energy in a reaction.

3. But-1-ene gas, C_4H_8 , undergoes an addition reaction with hydrogen gas, H_2 , to form butane gas, C_4H_{10} . Calculate the enthalpy change, $\Delta_r H^\ominus$, using the average bond enthalpies given in the table below.

Bond	Average Bond enthalpy (kJ/mol)
C-C	348
C=C	614
C-H	412
H-H	436

4. Pentan-1-ol combusts to form carbon dioxide and water. The following equation represents this reaction:
 $\text{C}_5\text{H}_{12}\text{O} + 7\frac{1}{2} \text{O}_2 \rightarrow 5\text{CO}_2 + 6\text{H}_2\text{O}$. Calculate $\Delta_r H^\ominus$ for pentan-1-ol, given the following enthalpy of formation data:
 $\Delta_f H^\ominus(\text{C}_5\text{H}_{12}\text{O}) = -298 \text{ kJ/mol}$, $\Delta_f H^\ominus(\text{CO}_2) = -394 \text{ kJ/mol}$, $\Delta_f H^\ominus(\text{H}_2\text{O}) = -286 \text{ kJ/mol}$
 $\Delta_r H^\ominus = \sum n \Delta_f H^\ominus(\text{products}) - \sum n \Delta_f H^\ominus(\text{reactants})$

TEST BANKS

The Test Banks have been curated to test student understanding of the chapter content. The Test Banks are **fully editable**, and provided in QTI and RTF formats, providing teachers with flexibility in how they deliver and use the questions. For example, encourage student participation by using the questions in fun Kahoot or Quizlet formats. Review the answers with the class for a quick refresher of key concepts and correct any commonly occurring misconceptions. Questions can be ingested into testing software or into a number of formats including Google forms, or a Google word document.

There are two Test Bank sets available for each chapter: a standard set and an extension set. These can be used for differentiated testing

Use the Test Banks at times that suit you, pick and mix questions to test understanding after an activity, at the conclusion of a learning sequence, or for a more substantial end of topic test.

Accessing the Test Banks:

Access to the Test Banks is complementary with multi-year purchases.

Please contact sales@biozone.com for access.

QUESTION LIBRARY

All questions in the *Chemistry Explained* worktext are extracted into Question Library files. Provided in QTI and RTF files, the questions can be ingested into a range of learning management systems or other digital delivery tools.

The Question Library content is **fully editable**, providing teachers with flexibility and control in assigning questions within a differentiated classroom. Teachers can customize the questions to match a student's ability or reading level.

Accessing the Question Library:

Access to the Question Library is complementary with multi-year purchases.

Please contact sales@biozone.com for access.

Section and Chapter Structure

Chemistry Explained consists of 12 chapters: 11 content chapters and a Science Practices and Data Analysis chapter. The content chapters deliver the course material and follow the same structure, making it easy to navigate through the title and utilize the inbuilt pedagogical features. Their structure and organization are explained below.

The Science Practices chapter contains activities to support students with the math and science practices associated with Chemistry Explained; students can refer to it at any time to support their learning. Information about utilizing the Science Practices and Data Analysis chapter can be found on page CG22.

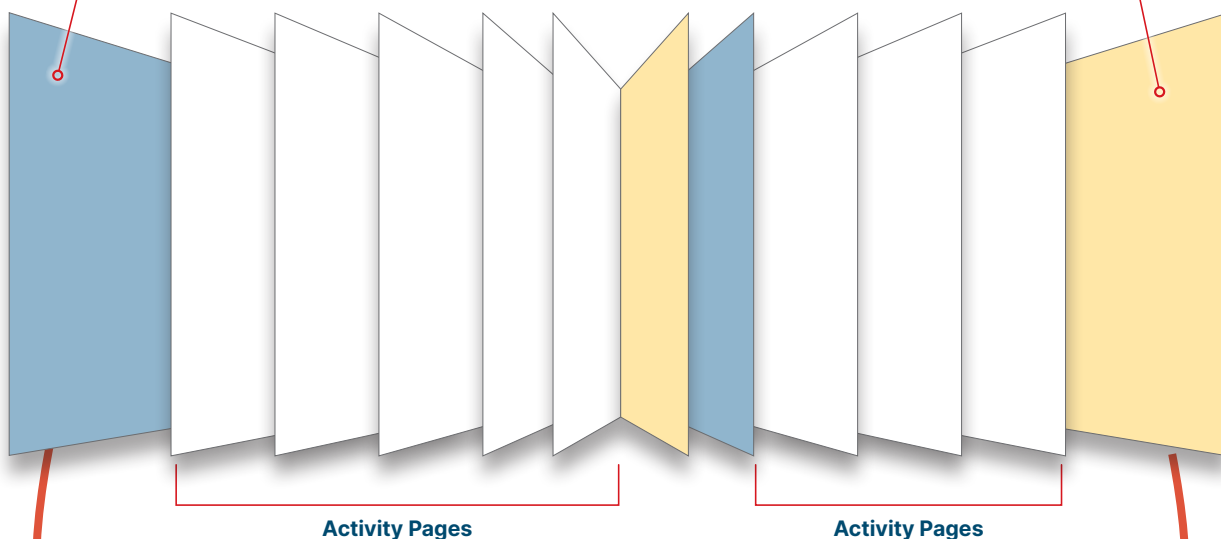
Structure of a Section and Chapter

Chapter introduction

Short statements summarize what students need to know for each chapter. Key terms and key concepts are also identified.

Did You Get It?

An assessment task allowing students to demonstrate their knowledge of the chapter's content.



Activity Pages

Activity Pages

Most activities have questions for students to answer. These form a record of work and demonstrate a student's understanding of the content.

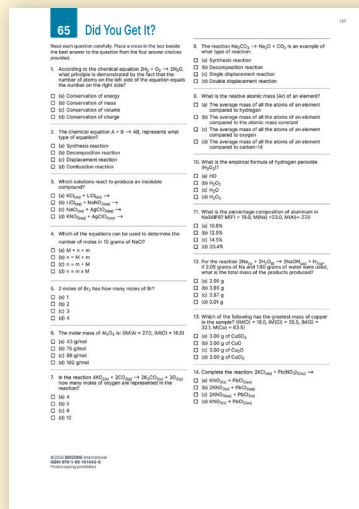
Chapter Introductions



The chapter introductions provide concise learning outcomes so students understand what they are expected to know or do by the end of the chapter.

Key vocabulary and key concepts are also highlighted here (see CG11).

Assessment: did you get it?



Each chapter has an end of chapter test. It allows you to test student understanding of the content covered.

Supplemental Assessments (CG8, CG17) and Test Banks (CG8, CG17) are also available.

The Contents: A Planning Tool

The contents pages are not merely a list of the activities. Encourage your students to use them as a planning tool for their program of work. Students can identify the activities they need to complete and then tick them off once completed. Ticking off the activities as they are finished gives students a sense of progression and helps them to be more personally organized in their work and time management. Teachers can see at a glance how a student is progressing through the set work. Any concerns with progress can be addressed early.

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Learning outcomes are clearly stated in the chapter introduction.

Ticking off the activities as they are completed gives students a sense of progression and helps them to be more personally organized in their work and time management.

You may have an alternative activity planned, students can use a cross mark to indicate they do not need to complete this activity.

A green circle indicates the activity contains a practical investigation.

Students can mark the check boxes to indicate the activities they should complete. This helps them to quantify the work to be done and plan their workflow.

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- 69 Entropy 146
- 70 Enthalpy 149

CODING Activity is marked: to be done when completed ● Practical Investigation

Chapter Introductions

Encourage students to interact with the chapter introductions as they work through the material as this will help them to understand key learning points for the course. The chapter introductions provide a concise list of learning outcomes that students should be able to demonstrate knowledge of by the time they complete the chapter. The chapter introduction also contains key concept and key term panels (see the example page below).

The key concepts provide a summary of the main points that students should take away from this chapter. Students can elaborate on the key concepts using the knowledge they have gained from completing the activities. The key terms draw students' attention to the language they should be using when studying chemistry. Encourage your students to use these terms regularly in their writing and oral communications to build scientific literacy. Definitions for the key terms can be found in the glossary section at the back of the worktext.

As students complete each activity, they can mark off their progress by ticking the relevant check-box on the chapter introduction page.

QR codes allows quick access to helpful resources (e.g. videos and 3D models) on BIOZONE's **Resource Hub**.

Chapter number and chapter title are identified for quick navigation.

Key terms

Important vocabulary students should understand and use during the course. Definitions are provided in the glossary at the back of the book.

Check boxes

Encourage students to use the check boxes to identify activities to be done (•) and to tick them off (✓) when the learning outcome is completed.

The screenshot shows a chapter introduction page for 'Atomic Structure and the Periodic Table'. It includes a QR code linking to a Resource Hub, a list of key terms, a key concepts section, a learning outcomes table, and a section on the periodic table and trends. Red arrows point from the surrounding text to specific elements on the page.

Chapter 2
Atomic Structure and the Periodic Table

Key Terms

- anion
- atom
- atomic number
- atomic radius
- Bohr model
- cation
- electron
- electron configurations
- electron repulsion
- electronegativity
- electrostatic attraction
- element
- energy level
- groups
- ion
- ionic radius
- ionization energy
- isotope
- period
- proton
- mass number
- mole
- neutron
- nuclear charge
- nucleus
- periodic table
- periodic trend
- relative atomic mass
- valence electrons
- valence shell

Key Concepts

- ▶ Knowledge of atoms and atom structure has been built up over a long time by the contributions of many different scientists.
- ▶ All matter consist of atoms which contain a nucleus with protons and neutrons, surrounded by electrons in energy levels.
- ▶ Elements are organized in a periodic table by increasing atomic number. Elements having similar properties are in the same groups.
- ▶ Atomic radius, ionization energy, and electronegativity show predictable patterns known as periodic trends across periods and down groups, .

Learning Outcomes:

Activity Number	Description	Page
1	Define the term, atom. Describe the purpose, results, and conclusions obtained from the 'gold leaf' experiment. Explain how the contributions of many (named) scientists contributed to the understanding of the structure of the atom as known today.	13-14
2	Draw an annotated model of the structure of the atom. Describe subatomic particles, including their charge (if any), location and size relative to each other. Define the term, mass number. Explain what is meant by the term, isotope, and define the components of nuclide notation.	15
3	Define valency and explain the meaning of valence electrons. Draw an annotated model of the electron configuration of an atom based on Bohr's model. Write electron configuration for the first 20 elements. Explain what is meant by ionization and describe the difference between cations and anions.	16
4	Define relative atomic mass and why it may not be a whole number. Explain the strong nuclear force and its role in keeping protons in the nucleus.	17

The periodic table and trends

5	Give a brief outline of the development of the periodic table and describe the key features of the modern layout.	18-19
6	Name the main blocks of the modern periodic table and give brief descriptions of the properties of the elements found in each block including their uses.	20
7	Describe some trends found in the periodic table and the reason for those trends. Include: atomic and ionic radii, first ionization energy, electronegativity.	21-26

Resource Hub
bit.ly/3Xkr4xp

Key concepts

These are the important key ideas for the chapter. Direct students to these and ensure they understand the concepts summarized here.

Learning outcomes

These provide a point by point summary of what students need to know or do by the end of the chapter. Teacher notes (CG30-CG48) provide guidance and suggestions for helping you deliver the learning outcomes.

Activity numbers

The activity number for each learning outcome is identified.

Features of the Activity Pages

The activity pages have been carefully designed to provide high quality information to students in an easily accessible format. They include a number of features designed to engage students and help them unpack and understand the information. Guide students through the features of the activity pages to ensure that they make the most of the material.

Features include:

- ▶ Short blocks of text and high quality informative graphics provide information in a way that prevents students feeling overwhelmed.
- ▶ **QR codes** link directly to 3D models (following page). These provide fun engagement and learning moments.
- ▶ Question and answer sections allow students to demonstrate their understanding of the content. By having the stimulus material and their answers in one place, students can easily revise for assessments.
- ▶ The **tab system** identifies when there is support material on the **Resource Hub**. Tabs also identify what section the activity is in (page CG14).
- ▶ **Link tabs** direct to related content or where support can be found to carry out a particular skill (see page CG14).

16

Electron Configuration

Activity number: Identifies the activity number to help navigation between activities.

Introductory paragraph: This provides background or introductory information to the topic.

Key Question: This provides a focus for the activity.

Key Question: Where are the electrons found and why is their location important?

The electrons in an atom are arranged in a series of energy levels.

Electrons move or 'orbit' around the **nucleus** in **energy levels** or shells. The energy levels further away from the nucleus are able to fit more electrons. The first energy level is filled first, followed by the second and so on until all the electrons (the same number as **protons** in an **atom**) have been used. A simple model, below, can be used to illustrate energy levels and electron placement.

Diagrams: Full color diagrams and photos help students visualize important information or concepts.

Electron pairs do not pair up because they have a property called spin (one of each pair is either up or down). In this configuration, they form the most stable position, equating to the lowest energy situation.

The outermost energy level is known as the **valence shell** containing **valence electrons**.

More information about the topic is provided through explanatory text, images, diagrams, case studies, and data.

QR codes: These provide a quick link to interactive 3D models.

Electron cloud model

▶ There are numerous models of the atom. The models shown above and in the previous activity are relatively simple. It is based on **Bohr's atomic model** and is not a true-to-life representation, nor is it meant to be.

▶ Since the development of Bohr's atom in 1913 there have been many improvements to it. This is not surprising and reflects the nature of science and advances in technology. The diagram right shows a model of the first electron shell of an atom based on the quantum atom developed by Erwin **Schrödinger** in 1926.

▶ In this model, electrons are not in fixed orbits but are found in a probability cloud around the nucleus.

▶ Although this model is more accurate than Bohr's, it is still a simplification of the true nature of the atom.

Activity based questions: Students input their answers directly onto the page (print and digital products) to help reinforce the learning moment. This approach also makes revision easy because the stimulus material and answers are in one place.

1. Suggest why the 1st energy level contains 2 electrons while the energy levels further out can contain up to 8 electrons:

Tab system: Identifies any Science and Engineering Practices, Crosscutting Concepts, or Applications of Chemistry context integrated into the activity.

The gray tab indicates support material is available on the **BIOZONE Resource Hub**.

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Using the QR codes on the pages

Some activities have QR codes on the pages (circled, below). These link directly to informative and engaging 3D models. If your school does not allow students to access phones in class time, students can still access the models through the Resource Hub and via BIOZONE WORLD. Students can either bookmark the Resource Hub or quickly access it using the bitly tag found on each chapter introduction (right).



Resource Hub

bit.ly/3Xkr4xp

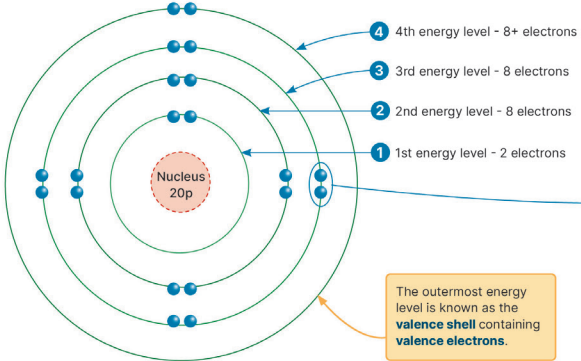
16

Electron Configuration

Key Question: Where are the electrons found and why is their location important?


The electrons in an atom are arranged in a series of energy levels.

Electrons move or 'orbit' around the **nucleus** in **energy levels** or shells. The energy levels are able to fit more electrons. The first energy level is filled first, followed by the second, and so on. The energy levels (the same number as **protons** in an **atom**) have been used. A simple diagram illustrates energy levels and electron placement.




4 4th energy level - 8+ electrons
 3 3rd energy level - 8 electrons
 2 2nd energy level - 8 electrons
 1 1st energy level - 2 electrons

The outermost energy level is known as the **valence shell** containing **valence electrons**.

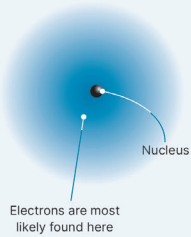


Electrons are grouped in pairs despite **electron-electron repulsion** because they have a property called **spin** (one of each pair is either up or down). In this configuration, they form the most stable position, equating to the lowest energy situation.



Electron cloud model

- ▶ There are numerous models of the atom. The models shown above and in the previous activity are relatively simple. It is based on **Bohr's atomic model** and is not a true-to-life representation, nor is it meant to be.
- ▶ Since the development of Bohr's atom in 1913 there have been many improvements to it. This is not surprising and reflects the nature of science and advances in technology. The diagram right shows a model of the first electron shell of an atom based on the quantum atom developed by Erwin **Schrödinger** in 1926.
- ▶ In this model, the orbital is shown as a blue cloud and electrons could be in any part of the cloud. An atomic orbital is a region around an atom's nucleus where there is a high probability of finding an electron. It describes the electron's likely location and energy level.
- ▶ Although this models help show the fuzzy nature of electron movement, they do not help us predict chemical reactions. Therefore, the simpler Bohr model is used typically for **electron configurations**.




Nucleus
Electrons are most likely found here


1. Suggest why the 1st energy level contains 2 electrons while the energy levels further out can contain up to 8 electrons:

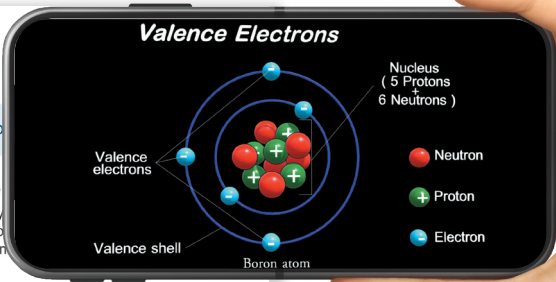
2. What would be a disadvantage of using Schrödinger's atom model to demonstrate atomic structure?

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SC







Understanding the Tab System

A tab system is found at the bottom of the first page of each activity. The colored tabs identify Crosscutting Concepts and Science and Engineering Practices contained within an activity. A purple tab indicates the activity contains application of chemistry knowledge. The gray tabs indicate whether support material is provided on BIOZONE's **Resource Hub**. Link tabs in the margin direct users to related ideas and concepts as well as links to specific skills. The tab system is explained below.

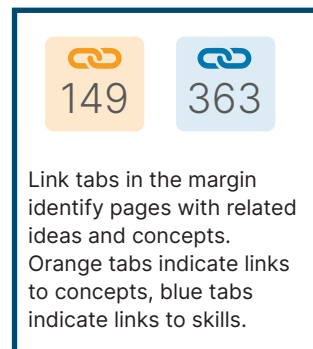
The **purple** APP tab indicates that the activity contains **Application of Knowledge** content which provides examples of how chemistry is used in the real world.

The gray hub tab indicates that the activity is supported online at the BIOZONE **Resource Hub**. Online support may include videos, animations, games, simulations, articles, 3D models, and computer models.










The **green** Crosscutting Concept tabs identify the Crosscutting Concept(s) associated with the activity. Students become familiar with the Crosscutting Concepts that connect all areas of science.








The **blue** Science and Engineering Practices tabs use picture codes to identify the Science and Engineering Practices (SEPs) specific to the activity.



Science and Engineering Practices

- 
Asking questions (for science) and defining problems (for engineering)
 Asking scientific questions about observations, processes, or content helps to define problems.
- 
Developing and using models
 Models can represent a system or a part of a system. Using models can help explain how a structure, process, or design works, and suggest improvements.
- 
Planning and carrying out investigations
 Investigations allow ideas and models to be tested and refined, and understood. Planning and carrying out these is an important part of independent research.
- 
Analyzing and interpreting data
 Collected data must be analyzed to reveal any patterns or relationships. Tables and graphs are two of the many ways to display and analyze data for trends.
- 
Using mathematics and computational thinking
 Mathematics is a tool for understanding scientific data. Using formulae and solving equations provides answers to quantitative problems. Converting or transforming data helps to show relationships.
- 
Constructing explanations (for science) and designing solutions (for engineering)
 Constructing explanations for observed phenomena is a process that may involve drawing on existing knowledge as well as generating new ideas.
- 
Engaging in argument from evidence
 New scientific ideas gain acceptance when they are argued for with evidence. Logical reasoning based on evidence allows the merit of new claims or explanations to be evaluated.
- 
Obtaining, evaluating, and communicating information
 Information must be evaluated for scientific accuracy or bias to determine its validity and reliability. Communicating information includes use of reports, graphics, oral presentation, and models.

Crosscutting Concepts

- 
Patterns
 Patterns are everywhere in nature. These guide how we organize and classify items and substances and prompt us to ask questions about the processes that create and influence them.
- 
Cause and effect
 Investigating and explaining causal relationships and their mechanisms can help explain and predict events and outcomes in new contexts.
- 
Scale, proportion, and quantity
 Different things are relevant at different scales. Changes in scale, proportion, or quantity affect the structure or performance of a system.
- 
Systems and system models
 Defining and modeling a system, e.g. physical, mathematical, or chemical provides a way to understand and test ideas.
- 
Energy and matter
 Energy flows and matter cycles. Tracking these fluxes helps us understand how systems function and the limits of that system.
- 
Structure and function
 The structure of a substance or object determines many of its properties and functions.
- 
Stability and change
 Science often deals with constructing explanations for how systems and objects change or how they remain stable.

Applications of Chemistry

Students can sometimes feel that the material they are learning in class doesn't relate to them or the world around them. To highlight the connection to the real world, we have included **Applications of Chemistry** boxes. These purple boxes connect chemistry to everyday life and help students see that it's more than just formulae and equations. Whether it's the science behind cooking, medicine, forensics, technology, or even the products they use daily, real-world examples make chemistry feel more relevant and accessible. These connections help students understand the practical importance of what they're learning, and make lessons more engaging and meaningful.

Relatable examples also make complex concepts easier to grasp. When students can link new ideas to familiar experiences, like soda becoming flat, charging their phones, or using a cold pack on a sprain, they develop a deeper understanding. Seeing chemistry in action encourages curiosity, critical thinking, and problem solving skills. By highlighting real-world applications, we help students build confidence in their learning and recognize how chemistry plays a role in shaping their future, whether in specific careers, everyday decisions, or innovations that affect society.

228 **102** Defining Acids and Bases

Key Question: What are the properties and definitions of acids and bases, and how do they interact in chemical reactions?

Properties of acids

- Acids are a group of substances that exhibit common acidic characteristics or properties, which are related to their chemical reactions with other substances.
- These properties include a sour taste, the ability to turn blue litmus paper red, and the capacity to react with metals to produce hydrogen gas.
- Acids can be categorized into two main types: organic acids and mineral acids.
 - Organic acids**, such as citric acid and acetic acid, are found naturally in plants and animals.
 - Mineral acids**, such as hydrochloric acid and sulfuric acid, are synthesized in laboratories and are commonly used in industrial processes.

Properties of bases

- Bases are a group of chemicals that can **neutralize** acids by removing hydrogen ions (H^+) from a solution.
- They exhibit properties that are opposite to those of acids. Bases typically have a slippery or soapy feel and can turn red litmus paper blue.
- Common household bases include substances such as baking soda, which is used in cooking and cleaning, floor cleaners, and antacid tablets that help relieve indigestion by neutralizing stomach acid.
- Bases are essential in various applications, from cleaning products to medical treatments, due to their ability to counteract acidity.

Application of Chemistry content is easily identified within a purple box on an activity page.

Most household cleaning liquids are bases and feel slippery when touched.

Preserving food in acid: in a pickle

Before modern refrigeration, pickling was essential for survival in many cultures. It allowed communities to make the most of their harvests and ensured a steady food supply throughout the year. This method of preservation also played a crucial role in trade, as pickled foods could be transported over long distances without spoiling.

Pickling involves immersing food in an acidic solution, typically vinegar (acetic acid) or a naturally fermented brine that produces lactic acid. The high acidity creates an environment that inhibits the growth of harmful bacteria, thus preserving the food.

In many European countries, pickling was a common way to preserve vegetables, e.g. cucumbers (to make pickles), cabbage (to make sauerkraut), and beets. This was especially important during the winter months when fresh produce was scarce.

In Korea, kimchi (fermented cabbage) is a staple food. It is made by fermenting cabbage with a variety of seasonings, including chili pepper, garlic, and ginger, in a brine that produces lactic acid.

Assorted pickled vegetables

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A purple **APP** tab indicates the activity contains Applications of Chemistry content.

Using the Application of Chemistry content in the classroom

Teachers can use the Applications of Chemistry sections in many ways to help students connect chemistry to the real world. Some suggestions are provided below:

- Class discussions:**
Begin with a discussion on the real-world example provided. Encourage students to share their own experiences or observations related to the topic. Use it as a launch pad to brainstorm how the particular chemistry concept plays a role in their daily life.
- Inquiry based learning:**
Use the example as a starting point for a research activity. Have students pose questions about the topic, research it further, and present their findings in small groups or to the class.
- Case studies & problem solving:**
Present the real-world scenario as a case study and ask students to analyze the chemistry behind it in more detail. They can work through problems related to the concept, such as calculating chemical quantities, predicting reactions, or evaluating the impact of a chemical process.
- Demonstrations & simulations:**
In some cases it may be possible to conduct a simple experiment or use a simulation related to the example. Sometimes a practical investigation is provided within the activity, or you could devise your own. Check the [BIOZONE Resource Hub](#) to see if there is a video, model, or simulation to support the concept.
- Creative assignments:**
Have students create their own "Applications of Chemistry" snapshots based on their personal interests. For example, they can research a chemical process related to sports, cosmetics, cooking, or technology and explain its real-world significance. Alternatively they could expand on one of the examples already provided.
- Debates & ethical discussions:**
If the example touches on environmental or societal issues, facilitate a class debate or discussion on the benefits, risks, or ethical considerations involved.
- Cross-curricular connections:**
Link the chemistry concept to other subjects where applicable. For example, links to history (the history and significance of specific chemical discoveries), economics (how chemistry can be used to reduce production costs and increase efficiencies), or environmental science (how catalytic converters reduce air emissions from vehicles).

Historical Perspectives

Understanding the historical contributions to chemistry helps students see that science is a dynamic, evolving field built on the work of many individuals over time. Learning about key figures such as Curie, Mendeleev, and Avogadro shows students how scientific discoveries are made, refined, and sometimes even challenged. These stories highlight the process of scientific inquiry and reinforce the idea that chemistry is not just a collection of facts but a growing body of knowledge shaped by experimentation, creativity, and collaboration.

Exploring historical perspectives also makes chemistry more engaging and accessible. When students learn about the challenges and breakthroughs of past scientists, they see that discovery often involves perseverance and problem-solving. These real-life examples can inspire students by showing them that scientific progress is driven by curiosity and determination. By connecting chemistry's past to the present, historical perspectives help students appreciate how discoveries continue to shape our world today.

Why so many male chemists?

Your students may ask why the majority of the historical perspectives feature male scientists. This reflects the fact that, historically, women had fewer opportunities to pursue scientific research, or that their contributions were not always recognized.

Many women have made important contributions to chemistry and several have won Nobel Prizes. You may wish to explore these contributions further to provide a broader view of important female figures in the field. An internet search of women in chemistry will provide a number of reputable sites listing important female chemists. Some notable female chemists include: Marie Curie (radioactivity chemistry), Irene Joliot-Curie (radioactivity chemistry), Marie-Anne Lavoisier (co-contributor to her husband's work and translator of scientific texts), Alice Ball (an African American chemist who developed an injectable oil to treat Leprosy), and Rosalind Franklin (chemist and crystallographer who played a key role in determining the structure of DNA). More contemporary chemists include Asima Chatterjee (organic chemist who developed anti-malaria and anti-epileptic drugs), Emmanuelle Charpentier and Jennifer Doudna (biochemists who pioneered CRISPR technology), and Stephanie Kwolek (inventor of Kevlar).

Using the Historical Perspective content in the classroom

You can develop the Historical Perspectives further if you want. This provides opportunities to extend some students, set research and reporting opportunities, or set extra credit projects. Some suggestions for utilizing these include:

1. Connecting Discoveries to Modern Chemistry

Ask students to research how a historical discovery laid the foundation for modern applications.

Example: Marie Curie discovered radium and polonium and was key to discovering radioactivity. How did these discoveries advance the field of radioactivity as a whole and the use of radioactive elements in modern medicine (PET scans), cancer treatment (radiotherapy), or nuclear energy?

2. Role playing or debates

Assign students historical figures and have them present their discoveries in a debate or as if they were at a scientific conference. Example: A debate between Bohr and Rutherford on atomic structure.

3. Timeline Activity

Have students create a timeline of key discoveries in chemistry, showing how understanding has developed over time.

Example: Show how the periodic table evolved from Mendeleev's early version to its current form.

4. Primary Source Analysis

Provide excerpts from scientific papers or letters and have students analyze the language, methods, and significance.

Example: Discuss excerpts from Marie Curie's work on radioactivity.

5. Discussing Barriers and Progress

Encourage discussion on how social and historical contexts influenced who was able to contribute to science.

Example: Compare the historical recognition of women in chemistry to their male counterparts.

6. Hands-on Historical Experiments

Recreate famous experiments or replicate models using classroom-friendly methods.

Example: Construct a model to show the set up of Rutherford's gold foil experiment.

7. Scientist of the Week

Assign students a scientist to research and present briefly to the class, highlighting their contributions and challenges.

99
Solubility Curves
221

Key Question: How do solubility curves help predict the solubility of different substances in various solvents at different temperatures?

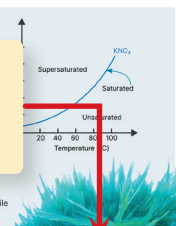
Modeling and predicting solubility

- ▶ Solubility curves are graphs that show how the solubility of a substance changes with temperature. They typically plot temperature on the x-axis and the amount of solute that can dissolve in a given amount of solvent on the y-axis. The curves vary depending on the solute and solvent.
- ▶ Recall from the previous activity that the solubility of most solids increases as the temperature rises, meaning more of the solid can dissolve in the liquid at higher temperatures. However, for gases, solubility usually decreases with an increase in temperature, meaning less gas can stay dissolved in the liquid as it gets warmer.
- ▶ These solubility curves help us understand and predict how much of a substance can dissolve in a liquid at different temperatures.

Interpreting solubility curves

Every solute, such as an ionic salt, has its own solubility

Historical Perspectives
content is highlighted within a yellow box on an activity page.



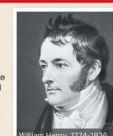
chloride (in crystal form, image right) show a rapid increase in solubility as temperature rises. In contrast, substances such as NaCl exhibit a more linear increase in solubility, while NaCl shows little increase with temperature rise.

William Henry - doctor and chemist

William Henry formulated Henry's Law in the early 19th century, which describes the solubility of gases in liquids and laid the groundwork for understanding solubility behavior in general.

Henry initially trained and practiced as a medical doctor. During the 19th century, the boundaries between different scientific disciplines were not as rigid as they are today. Many scientists, often referred to as "natural philosophers," pursued a broad range of interests and made contributions to various areas of science.

Other notable examples of multi-disciplinary scientists include Michael Faraday, who made significant contributions to both chemistry and physics, and Charles Darwin, who was trained in medicine and theology (religion) but is best known for his work in natural history and biology.



1. Suggest how solubility curves could be used by scientists:

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SF

CE

3

Evaluating Student Performance

While most activities require students to record a response (answer the questions provided), we do not recommend that every question is graded. In most instances, the activities have been designed so that student answers form an individual record of work, allowing students to review their answer within the context of the activity at any time.

We recommend teachers are selective about activities or questions they choose to review or grade to avoid assessment fatigue. Focus on content that students typically find challenging or on activities that cover essential material for the course. We highly recommend that end of chapter Did You Get It? assessments and the Supplemental Assessment tasks are graded. Both of these provide formal opportunities to test student understanding of the content. Find out more about the formative and summative assessment tasks below. The Test Banks also provide another way to test student understanding of the content.

Chapter assessments: Did You Get It?

Chapters 1-11 each conclude with a *Did You Get It?* assessment task. These have been designed to test student understanding of the chapter content and can be used to identify any gaps or misconceptions which still need to be addressed before moving on. Assessments consist of a mixture of multiple choice and free response questions (below). You may wish to use the chapter assessment as a practice test before asking students to complete the Supplemental Assessment task (right).

Supplemental Assessments

Supplemental Assessments are provided as alternative assessment tasks for each chapter. Unlike end of chapter "Did You Get It?" assessments, students do not see these tasks prior to you presenting them. There are a variety of questions types allowing students to demonstrate understanding and application of their acquired knowledge. The Supplemental Assessment tasks are provided through the Teacher Toolkit on the digital platform, BIOZONE WORLD. There are student versions (questions only) and teacher versions (with answers and grading suggestions provided).

65 Did You Get It?

Read each question carefully. Place a cross in the box beside the best answer to the question from the four answer choices provided.

- According to the chemical equation $2\text{H}_2 + \text{O}_2 \rightarrow 2\text{H}_2\text{O}$, what principle is demonstrated by the fact that the number of atoms on the left side of the equation equals the number on the right side?
 - (a) Conservation of energy
 - (b) Conservation of mass
 - (c) Conservation of volume
 - (d) Conservation of charge
- The chemical equation $\text{A} + \text{B} \rightarrow \text{AB}$, represents what type of reaction?
 - (a) Synthesis reaction
 - (b) Decomposition reaction
 - (c) Displacement reaction
 - (d) Combustion reaction
- Which **oxidation-reduction** reaction is **not** a **redox** reaction?
 - (a) KClO_3
 - (b) LiCl
 - (c) NaCl
 - (d) KNO_3
- Which **number** is correct?
 - (a) M
 - (b) n
 - (c) n
 - (d) n
- 2 moles
 - (a) 1
 - (b) 2
 - (c) 3
 - (d) 4
- The **mo**
 - (a) 43
 - (b) 75
 - (c) 85
 - (d) 102
- In **the**
 - (a) 4
 - (b) 5
 - (c) 8
 - (d) 12

8. The reaction $\text{Na}_2\text{CO}_3 \rightarrow \text{Na}_2\text{O} + \text{CO}_2$ is an example of what type of reaction?

- (a) Synthesis reaction
- (b) Decomposition reaction
- (c) Single displacement reaction
- (d) Double displacement reaction

9. What is the relative atomic mass (Ar) of an element?

- (a) The average mass of all the atoms of an element compared to hydrogen
- (b) The average mass of all the atoms of an element compared to the atomic mass constant
- (c) The average mass of all the atoms of an element compared to oxygen
- (d) The average mass of all the atoms of an element compared to carbon-12

10. What is the empirical formula of hydrogen peroxide?

- (a) HO

15. Balance the following equations:

- $\text{Ca} + \text{HCl} \rightarrow \text{CaCl}_2 + \text{H}_2$
- $\text{Li} + \text{H}_2\text{O} \rightarrow \text{LiOH} + \text{H}_2$
- $\text{Na}_2\text{CO}_3 + \text{HCl} \rightarrow \text{NaCl} + \text{H}_2\text{O} + \text{CO}_2$
- $\text{CuO} + \text{HCl} \rightarrow \text{CuCl}_2 + \text{H}_2\text{O}$

16. Complete the following reactions:

- $\text{Ca} + \text{O}_2 \rightarrow$
- $\text{Mg} + \text{H}_2\text{SO}_4 \rightarrow$
- $\text{MgCO}_3 + \text{HCl} \rightarrow$

For the remaining questions in this summative activity use the molar masses given: $\text{M(H)} = 1.0 \text{ g/mol}$, $\text{M(C)} = 12.0 \text{ g/mol}$, $\text{M(N)} = 14.0 \text{ g/mol}$, $\text{M(O)} = 16.0 \text{ g/mol}$, $\text{M(Na)} = 23.0 \text{ g/mol}$, $\text{M(S)} = 32.1 \text{ g/mol}$, $\text{M(Cl)} = 35.5 \text{ g/mol}$, $\text{M(Fe)} = 55.8 \text{ g/mol}$, $\text{M(Cu)} = 63.5 \text{ g/mol}$, $\text{M(Ba)} = 137.3 \text{ g/mol}$

17. Calculate the following:

- MNO_3
- $\text{M(C}_2\text{H}_5\text{)}$
- n(NaCl) in 10 grams of NaCl
- n(Cu) in 20 grams of CuSO_4
- n(H) in 20 grams of H_2O

18. A mining company wanted to mine copper ore. They had the choice of two sites. Site 1 contained ore with approximately 80% chalcocite (Cu_2FeS_2). The second site contained ore with approximately 70% bornite (Cu_5FeS_4). Determine which site will produce the greatest amount of copper.

19. The most common iron ores are haematite (Fe_2O_3) and magnetite (Fe_3O_4). To refine these ores they are reacted with carbon monoxide (CO). The reactions occur in up to three stages:

Stage One: $3 \text{Fe}_2\text{O}_3 + \text{CO} \rightarrow 2 \text{Fe}_3\text{O}_4 + \text{CO}_2$

Stage Two: $\text{Fe}_3\text{O}_4 + \text{CO} \rightarrow 3 \text{FeO} + \text{CO}_2$


Stage Three: $\text{FeO} + \text{CO} \rightarrow \text{Fe} + \text{CO}_2$

- At which stage would the extraction of iron begin at the site with the haematite ore?
- At which stage would the extraction of iron begin at the site with the magnetite ore?
- How many moles CO are needed to form 1 mole of Fe from haematite?
- How many moles CO are needed to form 1 mole of Fe from magnetite?
- Carbon monoxide is produced by reacting coke (C) with oxygen (O_2): $2\text{C} + \text{O}_2 \rightarrow 2\text{CO}$. Calculate the amount of coke required to refine 1 tonne of iron (Fe) from magnetite and haematite.

Supplemental Assessment

Ch 5: Thermochemistry

Student name: _____ Class: _____

- On the right is a melting bag of ice. The ice feels cold to the touch. Describe what type of reaction is occurring here, endothermic or exothermic and provide a reason:
 
- The enthalpy of fusion, $\Delta_{\text{fus}}H^\circ$, of water is $+6.01 \text{ kJ/mol}$. Write this equation:

- If the ice bag above contains 4.38 kg of ice, how much energy is required for all this ice to melt into water? (Molar mass of $\text{H}_2\text{O} = 18 \text{ g/mol}$, $n = m/M$)

- What changes in entropy are occurring in both the ice and surroundings? Use the second law of thermodynamics to justify the changes:

- Methanol and ethanol are both alcohols and they are used as fuels, in a similar way to butane. Their combustion reactions can be represented by the following equations:

Methanol combustion: $2\text{CH}_3\text{OH} + 3\text{O}_2 \rightarrow 2\text{CO}_2 + 4\text{H}_2\text{O}$ $\Delta_{\text{c}}H^\circ = -1450 \text{ kJ/mol}$

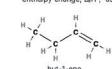
Ethanol combustion: $\text{C}_2\text{H}_5\text{OH} + 3\text{O}_2 \rightarrow 2\text{CO}_2 + 3\text{H}_2\text{O}$ $\Delta_{\text{c}}H^\circ = -1370 \text{ kJ/mol}$

Show with working, which fuel, methanol or ethanol, will produce more heat energy when 428 g of each fuel is combusted in excess oxygen (i.e. complete combustion). $\text{M(C}_2\text{H}_5\text{OH)} = 32.0 \text{ g/mol}$ $\text{M(C}_2\text{H}_5\text{OH)} = 46.0 \text{ g/mol}$
- Butane
 - Calc ZIC
 - Calc ZIC
 - Draw mol lab
 - Defi
 - But end
- A group of chemistry students decide to burn methanol in a calorimetry set up to calculate the enthalpy of combustion with their collected data. The students burned 5.12 g of methanol, and the temperature of 1 L water increased from 21.2°C to 34.2°C . (1 ml = 1 g) $q = m \times c \times \Delta T$ $n = c \times V$ $\Delta_{\text{c}}H^\circ = -q/n$

Using these results, calculate the experimental value of $\Delta_{\text{c}}H^\circ$ (CH_3OH).


The specific heat capacity of water is $4.18 \text{ J}^\circ\text{C}^{-1}\text{g}^{-1}$ $\text{M(C}_2\text{H}_5\text{OH)} = 32.0 \text{ g/mol}$
- The students found that their result does not match the accepted enthalpy change from their class data book. Discuss some potential errors that they could have made with their experimental set up to explain this difference:

- But-1-ene gas, C_4H_8 , undergoes an addition reaction with hydrogen gas, H_2 , to form butane gas, C_4H_{10} . Calculate the enthalpy change, $\Delta_{\text{c}}H^\circ$, using the average bond enthalpies given in the table below.



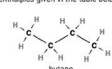
but-1-ene

+



hydrogen

=



butane

Bond	Average bond enthalpy, kJ/mol
C-C	346
C=C	614
C-H	414
H-H	436
- Pent-1-ene combusts to form carbon dioxide and water. The following equation represents this reaction:

 $\text{C}_5\text{H}_{10} + 7.5 \text{O}_2 \rightarrow 5\text{CO}_2 + 5\text{H}_2\text{O}$. Calculate $\Delta_{\text{c}}H^\circ$ for pent-1-ene, given the following enthalpy of formation data:

 $\Delta_{\text{f}}H^\circ$ (C_5H_{10}) = -285 kJ/mol $\Delta_{\text{f}}H^\circ$ (CO_2) = -394 kJ/mol $\Delta_{\text{f}}H^\circ$ (H_2O) = -286 kJ/mol

 $\Delta_{\text{c}}H^\circ = \sum n \Delta_{\text{f}}H^\circ(\text{products}) - \sum n \Delta_{\text{f}}H^\circ(\text{reactants})$

Practical Investigations

Throughout *Chemistry Explained*, students are given opportunities to explore through investigations. These are opportunities for students to develop competency in laboratory procedures, practice and refine skills in observation and analysis, manipulate data, and analyze findings. The investigations provide an excellent opportunity for collaborative work and will stimulate discussion and the sharing of ideas. You may wish to pair students of different abilities for these tasks. Confident students can guide and encourage less able students and by working together students can share their own observations and ideas. Collaboration through paired practical work provides an excellent opportunity for students to consolidate their scientific vocabulary, communication, and social skills. English language learners can interact in meaningful ways to practice and extend their English language skills.

Throughout the book, you will notice green investigation panels such as the one shown below. Each investigation uses simple materials and standard equipment found in most high school laboratories. *No special kits are required to carry out the investigations.* An equipment list for each investigation is provided at the back of the book (below, right).

Investigations

Each investigation is clearly numbered sequentially through the chapter.

Where applicable, the investigations provide students with health and safety information at the start of the investigation but it is important that you ensure students adhere to additional safety procedures stipulated by your school or state.

Encourage students to read through the procedure fully before beginning the investigation. You should highlight any hazardous or important steps where extra care may be required.

It is a good idea for students to have all the equipment assembled before they begin. They should identify any pinch points or time sensitive steps in the process. If necessary, have the groups allocate specific people to key steps, e.g. timing, collecting samples, recording data or observations etc.

Equipment list

The equipment list (at the back of the book) provides a list of all the materials required to carry out the practical investigations. Investigations are ordered by chapter and investigation number. Use the list to plan what equipment you need for individual investigations, or to plan the resources required for the entire year.

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78 Calorimetry Investigation

Key Question: How can we generate and collect temperature change data in the school laboratory in order to calculate energy change and the enthalpy of reaction?

Using experimental data to calculate the enthalpy of reactions

▶ **Calorimetry** is the science of measuring how much heat is gained or lost by a substance during a chemical reaction. It uses a device called a calorimeter to keep the substance isolated and measure the heat change.

This icon indicates students can work in pairs or groups.

The law of conservation of energy, which means that energy cannot be created or destroyed, only transferred from one place to another. By measuring the temperature change in the water, we can figure out how much heat is absorbed or released by the substance using this formula: $q = m \cdot c \cdot \Delta T$ that was explained in the previous activity.

Investigation 5.3 Measuring energy changes using a calorimeter

See appendix for equipment list.

Wear eye protection. Secure loose clothing and hair. Keep flammable materials away from the ethanol burner and handle the burner with care.

Objective: To measure and calculate the energy changes in a chemical reaction using a calorimeter.

1. Set up the apparatus: Place the calorimeter, or heat proof glass beaker above the ethanol burner using a clamp. Fill the calorimeter or beaker with a measured amount of water (e.g., 200 mL). Measure and record the initial temperature of the water using the thermometer.

2. Prepare the ethanol burner: Measure and record the initial mass of the ethanol burner using a balance. Place the ethanol burner under the calorimeter.

3. Conduct the experiment: Light the ethanol burner and allow it to heat the water in the calorimeter. Stir the water gently with the stirring rod to ensure even heating. Monitor the temperature of the water until it has increased by a significant amount (e.g., 20–30°C). Extinguish the burner and measure the final temperature of the water.

4. Measure the final mass of the ethanol burner: Allow the burner to cool and then measure and record its final mass. Record difference in mass in grams (g).

Clamp and stand
Record water volume
Record temperature
Heat proof mat

Caution warnings advise if protective equipment is needed, or if special care needs to be taken with the materials used. In addition, be sure to refer to, and adhere to your own school or state safety protocols.

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Appendix: Equipment List

1: Foundational Chemistry

INVESTIGATION 1.1 Observing chemical reactions and identifying compounds

Per group:

- Small bottles of 0.1 M and 1 M hydrochloric acid (HCl)
- Small bottle of 0.1 M sodium hydroxide (NaOH)
- 2 cm magnesium ribbon piece (Mg)
- Test tubes and rack
- 1 × 25 mL measuring cylinder
- Dropper
- 1 × 100 mL beaker
- Test tubes and rack
- Phenolphthalein indicator

INVESTIGATION 1.2 Modelling solid, liquid, and gas states

Per group:

- Solid samples (e.g., metal block, plastic block)
- Liquid samples (e.g., water, oil)
- Gas samples (e.g., air in a balloon, carbon dioxide from dry ice)
- 1 × 100 mL measuring cylinder
- 1 × 50 mL and 100 mL beakers
- Flasks of different shapes
- 2 × balloons
- Ruler
- Digital scales
- Stopwatch
- Syringe (without needle)
- Measuring tape

INVESTIGATION 1.3 Heating iced water

Per group:

- 50 g crushed ice
- Digital scales
- 1 × 100 mL beaker
- Thermometer
- Bunsen burner, tripod and gauze mat
- Stopwatch

INVESTIGATION 1.4 Exploring physical properties of matter

Per group:

- Metals (small piece): aluminum foil, copper wire, iron nails
- Ionic solids (around 10 g): table salt (sodium chloride), baking soda (sodium bicarbonate)
- Molecular solids (around 10 g): sugar (sucrose), paraffin wax
- Covalent network solids: graphite (pencil lead), silicon dioxide (sand)
- Bunsen burner and heat mat
- Heat-resistant gloves
- 1 × 100 mL beaker
- 1 × 100 mL measuring cylinder
- Digital scales
- Conductivity set (bulb, wires, battery)
- Hammer and ruler

INVESTIGATION 1.5 Separating gravel, iron, sand, and salt mixture

Per group:

- Mixture of gravel, sand, iron, and salt
- Sieve
- 2 × 100 mL beakers
- Filter paper
- Funnel
- Stirring rod
- Hot plate or Bunsen burner
- Evaporating dish
- Magnet

INVESTIGATION 1.6 Separating different ink colors using paper chromatography

Per group:

- 50 mL of solvent (e.g., water, rubbing alcohol, or acetone)
- Chromatography paper or filter paper
- Different colored water-soluble ink pens or markers
- A pencil
- A ruler
- Scissors
- 1 × 250 beaker or a glass jar
- Dropper or pipette

INVESTIGATION 3.3 Designing a conductivity and solubility investigation

Per group:

- Molecular solids found in the kitchen (e.g., sugar, candle wax, citric acid, cornstarch)
- 4 × 100 mL beakers
- Stirring rods or magnetic stirrers
- Measuring spoons or digital scale (for measuring 1 gram of each solid)
- Distilled water
- Small conductivity set (battery, wires, alligator clips, small bulb)

4: Chemical Reactions and Stoichiometry

INVESTIGATION 4.1 Investigating reactions

Per group:

- 10 cm Mg ribbon (and scissors)
- 50 mL 1 M hydrochloric acid (HCl)
- 20 mL 1 M sulfuric acid (H₂SO₄)
- 4–5 CaCO₃ chips
- 50 mL lime-water solution
- 10 g calcium carbonate (powdered)
- Steel (iron) wool
- Bunsen burner, heat mat, and tongs
- 1 × 100 mL conical flask
- 1 × 100 mL beaker
- 1 × 100 mL boiling tube, stopper, and delivery tube
- Test tubes and rack
- Digital scales
- Thermometer
- Universal indicator or litmus paper
- Wooden splint and matches

INVESTIGATION 4.2 Precipitation reactions

Per group:

- 0.1–0.5 M of the following ionic salt solutions in labeled 20 mL bottles:
 - Sodium chloride (NaCl)
 - Sodium carbonate (Na₂CO₃)
 - Silver nitrate (AgNO₃)
 - Barium chloride (BaCl₂)
 - Sodium hydroxide (NaOH)
 - Iron (II) sulfate (FeSO₄)
 - Iron (III) nitrate (Fe(NO₃)₃)
 - Potassium iodide (KI)
 - Lead nitrate (Pb(NO₃)₂)
 - Copper sulfate (CuSO₄)
 - Magnesium nitrate (Mg(NO₃)₂)
 - Sodium sulfate (Na₂SO₄)
- Test tubes and rack

2: Atomic Structure and the Periodic table

INVESTIGATION 2.1 Flame test for metal elements

Per student:

- Samples of metal salt solutions (1–2 M, around 20 mL of each): such as sodium chloride (NaCl), potassium chloride (KCl), calcium chloride (CaCl₂), copper(II) sulfate (CuSO₄), and lithium chloride (LiCl)
- Small bottle of 1 M hydrochloric acid (HCl)
- Bunsen burner and heat-resistant mat
- Nichrome wire loop
- Distilled water
- Test tubes and test tube rack

3: Bonding and Substances

INVESTIGATION 3.1 Modelling molecular geometry

Per student:

- 4 red and 2 white balloons
- 2 × 30 cm string
- Large macramé-style bead
- Bulldog clip

INVESTIGATION 3.2 Polarity of molecules

Per group:

- 100 mL distilled water
- 100 mL vegetable oil

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Supporting Students to Develop Chemistry Skills

Students may initially feel uncertain about performing calculations, writing and balancing equations, or mastering the range of techniques required in chemistry. To address these challenges, we have included a number of supportive tools and features that offer clear, step-by-step guidance. **How to guides** provide accessible explanations of key processes by breaking down the steps, while in-text **explanatory notes** clarify complex concepts as they arise. **Practice questions** are strategically placed to reinforce learning and help students apply their understanding in meaningful ways. Students can also access **answers** to odd numbered numeric questions to help them check their understanding. Together, these features are designed to build both confidence and competence, making the essential skills of chemistry more accessible for all learners. More information is provided below and on the following page.

HOW TO guides

An important part of learning chemistry involves working with numbers, formulae, equations, and processes. Approaching these elements through a logical, step-by-step method makes them more manageable and helps students develop proficiency and mastery over time.

“How to...” boxes provide clear, step-by-step instructions for solving different types of equations or carrying out key processes. They also lay out the rules that apply to specific situations, helping students understand when and how to apply them. Worked examples are included to model problem-solving strategies and allow students to check their own working as they progress.

“HOW TO...” index

An index of all the “How to guides can be found in the appendix, on page 378. The guides are organized by chapter and activity for easy reference.

Draw your students’ attention to this resource, and encourage them to refer to it often, especially if they need clarification on any of the skills covered.

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60 Stoichiometry and Mole Ratios

Key Question: How is the stoichiometry of a reaction used to calculate product yield?

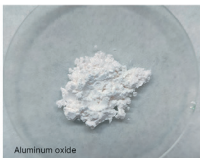
A balanced chemical equation provides the **stoichiometry** for a reaction. Recall that stoichiometry studies the mole ratios and the amount of each substance in a reaction. So far, you have used stoichiometry in a limited way. In the following set of activities you will use stoichiometry for the gravimetric analysis of various reactions.

▶ Recall that for a reaction, e.g. $2\text{Al}(s) + 3\text{O}_2(g) \rightarrow 2\text{Al}_2\text{O}_3(s)$, the stoichiometry for the reactants and products is 2:3:2. That is, for every 2 moles of aluminum and 3 moles of oxygen gas, 2 moles of aluminum oxide are formed.

▶ From this, it is possible to calculate and predict the product yield of a reaction or the amount of reactants required to form a particular amount of product.

▶ For example, should we wish to form 4 moles of Al_2O_3 , then it can be seen that 4 moles of aluminum and 6 moles of oxygen gas will be needed.

▶ Furthermore, if we wanted to form exactly 153 grams of aluminum oxide ($n(\text{Al}) = 3$) then we would need exactly 81 grams of aluminum.



Aluminum oxide

HOW TO Use reaction stoichiometry to predict product yield (in moles)

For the reaction $\text{C}_3\text{H}_8(g) + 5\text{O}_2(g) \rightarrow 3\text{CO}_2(g) + 4\text{H}_2\text{O}(l)$ calculate the moles of CO_2 produced if 2 moles of C_3H_8 is fully combusted with O_2 .

- Write down the stoichiometry of the reaction: 1:5:3:4.
- Identify the important reactants and products for the calculation: Reactant: $2\text{C}_3\text{H}_8$. Product XCO_2 .
- Write down mole ratio of reactant to product: 1:3.
- Use ratio to produce the conversion factor. Three times more moles of CO_2 will be produced than are moles of C_3H_8 combusted. So the conversion factor is 3/1: ($3\text{CO}_2/1\text{C}_3\text{H}_8$). (Unknown (CO_2) on top).
- Calculate the moles of CO_2 : $2\text{C}_3\text{H}_8 \times 3\text{CO}_2/1\text{C}_3\text{H}_8 = 6\text{CO}_2$ (note the C_3H_8 cancels in the equation).

- (a) Balance the equation: $\text{Ti}(s) + \text{N}_2(g) \rightarrow \text{Ti}_3\text{N}_4(s)$
(b) If 2 moles of Ti are used, how many moles of Ti_3N_4 are produced?
- (a) Balance the equation: $\text{Al}(s) + \text{ZnCl}_2(aq) \rightarrow \text{AlCl}_3(aq) + \text{Zn}(s)$
(b) If 2 moles of aluminum are used, how many moles of Zn will be produced?
(c) If 5 moles of AlCl_3 are produced, how many moles of Al were used?
- (a) Balance the equation: $\text{Na}(s) + \text{O}_2(g) \rightarrow \text{Na}_2\text{O}(s)$
(b) How many moles of Na_2O are produced using 4 moles of Na?
(c) How many moles of Na are needed to produce 5 moles of Na_2O ?
(d) How many moles of Na_2O are produced using 3 moles of O_2 ?

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HOW TO Use reaction stoichiometry to predict product yield (in moles)

For the reaction $\text{C}_3\text{H}_8(g) + 5\text{O}_2(g) \rightarrow 3\text{CO}_2(g) + 4\text{H}_2\text{O}(l)$ calculate the moles of CO_2 produced if 2 moles of C_3H_8 is fully combusted with O_2 .

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- Calculate the moles of CO_2 : $2\text{C}_3\text{H}_8 \times 3\text{CO}_2/1\text{C}_3\text{H}_8 = 6\text{CO}_2$ (note the C_3H_8 cancels in the equation).

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Yellow explanatory boxes

Some aspects of chemistry, such as interpreting graphs, reading chemical formulae, or understanding multi-step equations, can be confusing at first glance. Long paragraph explanations can sometimes add to the confusion rather than resolve it. To address this, *Chemistry Explained* uses boxed annotations that break down complex visual information into manageable parts. These annotations are placed alongside tables, graphs, equations, and chemical formulae to clarify their structure and purpose.

For example, in an equation like the one below, boxed notes might explain the meaning of each symbol, the relevance of subscripts and coefficients, or why certain steps are followed in balancing it.

These visual cues support students in making sense of unfamiliar representations and help them build the skills needed to interpret data and symbols independently over time.

2Al_(s) + 3Br_{2(l)} → 2AlBr_{3(s)}

- The aluminum is in a solid state.
- There are two units of aluminum.
- There are three units of molecular bromine.
- The bromine is in a liquid state.
- The arrow means 'reacts to form.'
- Each bromine is made of two Br atoms.
- 2 units of aluminum bromide are formed.
- The aluminum bromide is in a solid state.
- Aluminum bromide is made of one Al atom and three Br atoms.

44 Chemical Equations

Key Question: What information is in a chemical equation?

Reaction equations

A chemical reaction is the rearranging of the atoms in reactants to produce new products. The reactions can be very slow and barely noticeable, or fast and highly energetic.

A chemical reaction is written as: Reactants → Products
The reaction shown on the right is between aluminum powder and bromine liquid. The product of the reaction is solid aluminum bromide:



It is worth looking at this simple reaction in more detail because the reaction equation conveys a lot of information:

- The aluminum is in a solid state.
- There are two units of aluminum.
- There are three units of molecular bromine.
- The bromine is in a liquid state.
- The arrow means 'reacts to form.'
- Each bromine is made of two Br atoms.
- 2 units of aluminum bromide are formed.
- The aluminum bromide is in a solid state.
- Aluminum bromide is made of one Al atom and three Br atoms.

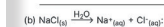
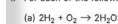


It can also be seen from the equation that everything on the left-hand side of the equation is present on the right-hand side of the equation: 2 Al and 6 Br appear on the left and 2 Al and 6 Br appear on the right. This is called the **conservation of mass**. Note that the mass could be the mass in grams or the number of atoms or molecules. In this case, the amounts are useless for simplicity but the correct units will be investigated in later activities.

Notice also, that the state of the reactants and products are shown in parentheses. This provides useful information about the reactants and products. Subscripted states may be:

- gas (g)
- liquid (l)
- solid (s)
- aqueous (aq) (dissolved in water).

1. For each of the following, write down in full the information conveyed by the reaction equation:



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Teacher Tip:

Encourage students to read the boxed annotations aloud in small groups and discuss what each one means. This promotes collaborative interpretation and helps students verbalize their thinking. Develop this into an activity if you wish by having students cover the annotations and try to explain it themselves. Then, reveal the annotations and discuss how they clarify or enhance the interpretation. The boxes can also be used for differentiation. For students who struggle with the concepts, walk through the annotations with them before continuing with the activity.

Model answers for students

Students are provided with answers to odd numbered numeric questions (questions involving calculations or equations) on page 382 of the appendix. This tool offers students valuable support as they develop their confidence in problem-solving. Access to worked examples allows students to independently check their understanding, identify and correct mistakes, and reinforce effective strategies. This fosters greater confidence and encourages self-directed learning.

At the same time, withholding answers for even-numbered questions ensures that students still engage in meaningful practice without relying solely on provided solutions. This balance promotes both guided learning and genuine application of skills.

Model answers for teachers

Teachers have access to the answers for ALL of the questions in the worktext. These are located in place on the printed and digital Teacher's Edition.

382

Answers to Numeric Questions

Odd numbers only

Ch 1: Foundational Chemistry	87: 7(4) 105.5 g 87: 9(4) 0.156 moles 87: 10(4) 0.0050 g 87: 11(4) 0.4 moles 87: 12(4) 0.8 moles 87: 13(4) 0.8 g 87: 14(4) 4.3 g 87: 15(4) 2.0 g 87: 16(4) 1.64 grams 87: 17(4) 0.208 moles 87: 18(4) 0.41 grams 87: 19(4) 0.208 moles 87: 20(4) 11 87: 21(4) 25 moles, 6.87 moles 87: 22(4) 2.8 87: 23(4) 2.8, 8	77: 5 125 kJ 77: 7 432 77: 9 152 kJ/mol 77: 11 -438 kJ/mol 77: 13 -282.28 kJ/mol 77: 15(4) 1658 kJ/mol 77: 16(4) 173 kJ/mol 77: 17(4) 2550 kJ/mol 77: 19 -852 kJ/mol 77: 21 338 kJ/mol 80: 3 -383 kJ/mol 80: 5 -6300 kJ/mol	Ch 11: Nuclear Chemistry 158: 3 82-lead 158: 5 59 days Ch 12: Science Practices 167: 1 21.7 mL, 21.83 mL 170: 1(4) 14 170: 3(4) 48 °C 171: 3(4) 38 g	
Ch 2: Atomic Structure and the Periodic Table	15: 3(4) 18 15: 3(4) 10 15: 3(4) 13 15: 3(4) 8	80: 2(4) 2 moles 80: 3(4) 6 moles 80: 4(4) 6 moles 80: 5(4) 3 moles 80: 6(4) 6 moles 80: 7(4) 2.8 moles 80: 7(4) 3.3 moles 81: 1(4) 0.08 moles 81: 1(4) 0.12 moles 81: 1(4) 15.2 grams 81: 1(4) 16.1 grams 81: 2 18.05, 19.34 g 81: 5(4) 0.67 moles 81: 5(4) 0.87 moles 81: 5(4) 85.8 grams 81: 5(4) 2.0 grams 82: 1(4) 61.9 82: 1(4) 3.8 g 82: 1(4) 158.6 g/mol 82: 1(4) 0.04 moles 82: 1(4) 2.2 g 82: 1(4) 18 g/mol 82: 1(4) 0.22 moles 82: 1(4) 15 82: 1(4) 0.59 grams 82: 1(4) 1.0 g 82: 1(4) 2.1 g 82: 1(4) 2.2 g 82: 1(4) 1.1 g 82: 1(4) 6.04 grams	85: 5(4) 0.80 moles 85: 6(4) 1.8 85: 6(4) 5.42 mol/L 100: 1 0.448 mol/L 100: 2 20.05 100: 3 20.05 M 100: 4 0.800 M 100: 5 488 mL 100: 6 1.87 100: 7 2.26 100: 8 5.90 100: 9 11.8 100: 10 1.00 100: 11 1.0×10^6 mol/L 111: 1 2.49 g 111: 3 0.60 g 112: 0 0.108 mol/L	Ch 7: Substances in Solutions 85: 5(4) 0.80 moles 85: 6(4) 1.8 85: 6(4) 5.42 mol/L 100: 1 0.448 mol/L 100: 2 20.05 100: 3 20.05 M 100: 4 0.800 M 100: 5 488 mL 100: 6 1.87 100: 7 2.26 100: 8 5.90 100: 9 11.8 100: 10 1.00 100: 11 1.0×10^6 mol/L 111: 1 2.49 g 111: 3 0.60 g 112: 0 0.108 mol/L
Ch 3: Bonding and Substances	22: 1(4) 2.8 22: 1(4) 2.8, 8	82: 1(4) 158.6 g/mol 82: 1(4) 0.04 moles 82: 1(4) 2.2 g 82: 1(4) 18 g/mol 82: 1(4) 0.22 moles 82: 1(4) 15 82: 1(4) 0.59 grams 82: 1(4) 1.0 g 82: 1(4) 2.1 g 82: 1(4) 2.2 g 82: 1(4) 1.1 g 82: 1(4) 6.04 grams	Ch 8: Reaction Rate and Equilibrium 87: 5(4) 0.13 87: 7(4) 0.0500 mol/L	Ch 9: Gases and Gas Laws 137: 1(4) 500.00 kPa 137: 1(4) 1.66 atm 137: 1(4) 214.8 mmHg 137: 1(4) 33.89 kPa 138: 1 3.00 atm 138: 2 6.06 atm 138: 3 6.0 atm 138: 4 2.1 138: 5 1.2 atm 138: 6 1071 kPa 138: 7 8.53 grams 138: 8 2524 grams
Ch 4: Chemical Reactions and Stoichiometry	53: 3(4) 3 53: 3(4) 5 53: 3(4) 5 53: 3(4) 14 53: 3(4) 6 53: 3(4) 14 53: 3(4) 5 53: 3(4) 3 54: 3(4) 2 54: 3(4) 79.5 54: 3(4) 18 54: 3(4) 105.6 54: 3(4) 44 54: 3(4) 78 g/mol 54: 3(4) 48 g/mol 54: 3(4) 16 g/mol 54: 3(4) 62.9 g/mol 54: 3(4) 96.9 g/mol 54: 3(4) 82.9 54: 3(4) 72.9 g 54: 3(4) 175.6 g 54: 3(4) 1.3 moles 54: 3(4) 1.3 moles 54: 3(4) 2.0 moles 54: 3(4) 0.0315 moles 54: 3(4) 0.0315 moles 54: 3(4) 2.0 g 54: 3(4) 7.5 g 54: 3(4) 106 g/mol 54: 3(4) 0.028 moles 54: 3(4) 0.057 moles 54: 3(4) 1.37 g 54: 3(4) 0.45 g 54: 3(4) 2.03 54: 7 727 g 57: 1(4) 32.0 g/mol 57: 1(4) 32.0 g 57: 3(4) 56.1 g/mol 57: 3(4) 56.1 g 57: 5(4) 71.4 g/mol 57: 5(4) 4.8 moles 57: 7(4) 162.3 g/mol 57: 7(4) 162.3 g 57: 7(4) 3 moles	87: 7(4) 105.5 g 87: 9(4) 0.156 moles 87: 10(4) 0.0050 g 87: 11(4) 0.4 moles 87: 12(4) 0.8 moles 87: 13(4) 0.8 g 87: 14(4) 4.3 g 87: 15(4) 2.0 g 87: 16(4) 1.64 grams 87: 17(4) 0.208 moles 87: 18(4) 0.41 grams 87: 19(4) 0.208 moles 87: 20(4) 11 87: 21(4) 25 moles, 6.87 moles 87: 22(4) 2.8 87: 23(4) 2.8, 8 80: 2(4) 2 moles 80: 3(4) 6 moles 80: 4(4) 6 moles 80: 5(4) 3 moles 80: 6(4) 6 moles 80: 7(4) 2.8 moles 80: 7(4) 3.3 moles 81: 1(4) 0.08 moles 81: 1(4) 0.12 moles 81: 1(4) 15.2 grams 81: 1(4) 16.1 grams 81: 2 18.05, 19.34 g 81: 5(4) 0.67 moles 81: 5(4) 0.87 moles 81: 5(4) 85.8 grams 81: 5(4) 2.0 grams 82: 1(4) 61.9 82: 1(4) 3.8 g 82: 1(4) 158.6 g/mol 82: 1(4) 0.04 moles 82: 1(4) 2.2 g 82: 1(4) 18 g/mol 82: 1(4) 0.22 moles 82: 1(4) 15 82: 1(4) 0.59 grams 82: 1(4) 1.0 g 82: 1(4) 2.1 g 82: 1(4) 2.2 g 82: 1(4) 1.1 g 82: 1(4) 6.04 grams	77: 5 125 kJ 77: 7 432 77: 9 152 kJ/mol 77: 11 -438 kJ/mol 77: 13 -282.28 kJ/mol 77: 15(4) 1658 kJ/mol 77: 16(4) 173 kJ/mol 77: 17(4) 2550 kJ/mol 77: 19 -852 kJ/mol 77: 21 338 kJ/mol 80: 3 -383 kJ/mol 80: 5 -6300 kJ/mol	Ch 5: Thermochemistry 72: 1 -632 kJ 72: 3 589 kJ 72: 5 16.7 mol 72: 7 48.1 mol 72: 9 -50.075 kJ 72: 9 52.2 kJ 72: 9 -798.25 kJ, -889 kJ 72: 7 -213.2 kJ, -389 kJ 74: 1 -2005.7 kJ/mol 74: 2 -282.5 kJ/mol 75: 7 -189 kJ 75: 9 -1389 kJ 76: 3(4) 10.44 J 76: 3(4) 45.5 kJ
Ch 5: Thermochemistry	72: 1 -632 kJ 72: 3 589 kJ 72: 5 16.7 mol 72: 7 48.1 mol 72: 9 -50.075 kJ 72: 9 52.2 kJ 72: 9 -798.25 kJ, -889 kJ 72: 7 -213.2 kJ, -389 kJ 74: 1 -2005.7 kJ/mol 74: 2 -282.5 kJ/mol 75: 7 -189 kJ 75: 9 -1389 kJ 76: 3(4) 10.44 J 76: 3(4) 45.5 kJ	Ch 6: Redox Reactions and Electrochemistry 127: 1(4) Pb + 4.0 = 2 127: 1(4) Mg + 2.0 = 2 127: 1(4) Cu + 1.0 = 2 127: 1(4) Zn + 2.0 = 2 127: 1(4) Fe + 3.0 = 2 127: 1(4) V ³⁺ + 2.0 = 2 127: 1(4) V ⁴⁺ + 2.0 = 2 127: 1(4) V ⁵⁺ + 5.0 = 2 127: 1(4) V ⁶⁺ + 6.0 = 2 127: 1(4) V ⁷⁺ + 7.0 = 2 127: 1(4) Ni ₂ CO ₃ + 3.0 = 2 127: 1(4) Ni ₂ CO ₃ + 3.0 = 2	Ch 6: Redox Reactions and Electrochemistry 127: 1(4) Pb + 4.0 = 2 127: 1(4) Mg + 2.0 = 2 127: 1(4) Cu + 1.0 = 2 127: 1(4) Zn + 2.0 = 2 127: 1(4) Fe + 3.0 = 2 127: 1(4) V ³⁺ + 2.0 = 2 127: 1(4) V ⁴⁺ + 2.0 = 2 127: 1(4) V ⁵⁺ + 5.0 = 2 127: 1(4) V ⁶⁺ + 6.0 = 2 127: 1(4) V ⁷⁺ + 7.0 = 2 127: 1(4) Ni ₂ CO ₃ + 3.0 = 2 127: 1(4) Ni ₂ CO ₃ + 3.0 = 2	

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Answers to odd numbered numeric questions are found on page 382 of the student and teacher edition.

Using the Foundational Chemistry Chapter

The Foundational Chemistry chapter provides a valuable starting point for your chemistry course. It is designed to bridge knowledge gaps, support students who may be new to the subject, and ensure a more consistent baseline of understanding across the class. By introducing fundamental principles early, this chapter lays the groundwork for more complex topics and helps build student confidence from the outset. Teachers can use this chapter in several ways:

Introducing Core Knowledge:

The chapter explains essential chemistry concepts for students with little prior experience. It helps bring all students to a common starting point, ensuring they are ready to engage with the rest of the course material.

Reinforcing Prior Learning:

For students who have encountered chemistry in earlier years, the chapter provides an opportunity to review and reinforce foundational skills and knowledge, setting them up for success in high school chemistry.

Assessing Prior Knowledge:

The chapter serves as an effective diagnostic tool to establish prior knowledge. Teachers can use the content to assess students' existing understanding, identify knowledge gaps or misconceptions, and adjust instruction to meet students' needs accordingly.

Establishing Good Laboratory Practices:

Use this chapter to set expectations for safety in the laboratory. It introduces basic laboratory equipment, proper handling techniques, and foundational safety protocols, ensuring that students are prepared for practical work throughout the year.

Engaging Students with Practical Activities:

Many of the early topics in this chapter lend themselves to hands-on, collaborative activities. Students might classify materials based on physical properties, create and separate mixtures, or conduct simple investigations such as separation of substances using paper chromatography. These tasks help students engage with chemistry in a tangible, accessible way while reinforcing key concepts, laboratory skills, and safe practices.

By using the Foundational Chemistry chapter strategically, teachers can create a strong start to the year that supports all students in building a lasting understanding of chemistry.



How are Language Skills Supported?

BIOZONE provides several supports to help students develop their language skills. We use language that is appropriate for high school students, with a focus on clear and direct wording, including in the way questions are phrased, to promote readability and understanding. Collaborative tasks are included to build students' communication and listening skills, and regular opportunities for students to formulate and input written responses supports the development of their writing skills. A glossary offers clear definitions of terms and helps students build scientific literacy. On our digital platform, BIOZONE WORLD, a translation function is available to support English Language Learners (ELLs) in their learning journey. More detailed information about these supports is provided below.

The glossary: helping you build your science vocabulary

Building chemistry vocabulary is important to help students understand ideas and communicate information about what they know. We have identified key terms and provided a glossary to help students build their scientific vocabulary.

Key terms: chapter introduction

Each chapter introduction has a list of key terms. These important words are defined in the glossary at the back of the book. Encourage students to use these terms as they communicate with their classmates and you.

Key terms: activities

Some words in an activity are written in **blue bold**. This is because they are key terms. If students are unsure of their meaning, they can refer to the glossary at the back of the book for the definition.

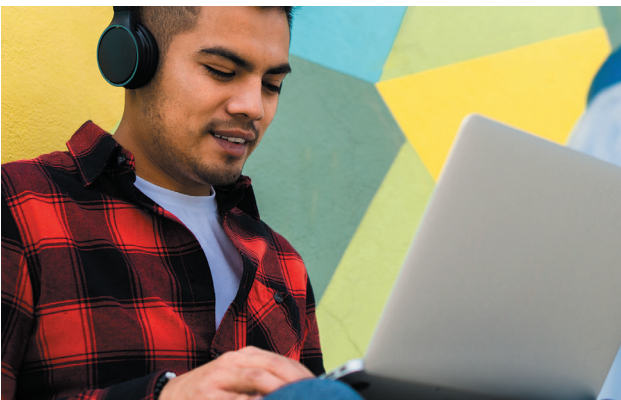
Glossary

A glossary of key terms is located at the back of the *Chemistry Explained* workbook. Students can use the glossary to find definitions for key terms.

Translation function

BIOZONE WORLD, our digital platform, provides a translation feature to support students who have English as an additional language. The content can be translated into ~150 languages.

Activate the translation feature, choose the desired language, and hover the cursor over the text to translate. A pop-up box with the translated text will appear, while the original English text remains visible. This dual-language view helps students develop their English language skills while providing the comfort of having their first language readily accessible.



Differentiated Learning Tools

Chemistry Explained promotes differentiated instruction and has been designed to cater for students with a wide range of abilities. There are several ways you can utilize the tools in the Chemistry Explained program to support differential instruction in your classroom.

19 The Modern Periodic Table

Key Question: How are elements organized in the modern periodic table?

Key Features of the periodic table

- The periodic table organizes elements by atomic number. The elements increase in atomic number as you move from left to right and from top to bottom of the periodic table.
- Each element has an atomic number which tells you how many protons an atom of that element has. This number is indicated by an equal number of electrons which surround the nucleus. The periodic table starts with hydrogen (H), atomic number 1 and ends with elements that have over 100 protons, such as oganesson (Og), atomic number 118.
- The periodic table is organized into groups that show a pattern, numbered from 1 to 18 from left to right, and periods that go across a row, numbered 1 to 7 from top to bottom.

1. Elements fluorine (F) and neon chemical properties. They have very different chemical properties.

2. Suggest why hydrogen is not considered a noble gas.

A number of elements are synthetic and not found in nature on Earth. Considering what you know about isotopes from previous activities, suggest why this is. Hint: consider the atomic mass of these synthetic elements.



Chemistry Explained

Chemistry Explained Resource Hub provides links to online content that supports the activities in the book. From this page, you can also check for any areas or publications in the book or learn more about our pricing.

The external website you are the most part, frequently focused activities and other sites directly related to the content of the activity in which they are used. They provide great support to help your understanding.

Level 1: Foundational Chemistry

1. Chemistry
2. Changing the High Equipment
3. Safety in the Lab
4. Classifying Matter
5. States of Matter
6. Changing States
7. Chemical and Physical Change
8. Physical Properties of Matter
9. Mixtures
10. Separating Mixtures
11. Paper Chromatography

Level 2: Atomic Structure and the Periodic Table

12. Introduction to the Atom
13. Describing Atomic Structure
14. Atomic Structure
15. Electron Configuration
16. Atomic Mass, Isotopes, and Atomic Weight
17. Development of the Periodic Table
18. Periodic Trends: Electronegativity
19. The Modern Periodic Table
20. A closer look at Element groups
21. Periodic Trends
22. Periodic Trends: Atomic and Ionic Radii
23. Periodic Trends: Ionization Energy
24. Periodic Trends: Electronegativity

Level 3: Bonding and Substances

25. Types of Chemical Bond
26. Ionic Bonding
27. Writing Ionic Compound Formulae
28. Covalent Bonding
29. London Dispersion Forces
30. Molecular Orbital Theory
31. Hydrogen Bonding
32. Types of Solid Substances

Extension Questions: Red flag icons beside a section or question (in the Teacher's Edition) indicate that the material is suitable for extending capable students. Other students can attempt the material too, but they may need extra guidance from the teacher. **Resource Hub extension:** Some material on the **Resource Hub** is tagged as extension material.

Test Banks: Two levels of Test Banks (standard and extension) allow for differentiated assessment. Both sets are fully editable, allowing teachers to further customize the questions to suit student ability. Copying and pasting the questions into a translation tool (e.g. Google Translate) allows for language conversion if required.

Resource Hub BIOZONE's **Resource Hub** supports learners of all abilities. The videos, 3D models, and interactives can be used by all students but are particularly helpful for supporting striving learners to understand content. Some material on the **Resource Hub** has been specifically tagged for students needing extension.

23 Periodic Trends: 1st Ionization Energy

Key Question: Why is the 1st ionization energy different across periods and down groups of the periodic table?

The 1st ionization energy? The 1st ionization energy is the energy required to remove an electron from the outermost shell of an atom. The 1st ionization energy specifically refers to the energy required to remove one mole of electrons from the outermost shell of one mole of atoms in the gaseous state. The ionization energy is high, that means it takes a lot of energy to remove the outermost electron. If the ionization energy is low, that means it takes a small amount of energy to remove the outermost electron.

A mole is chemistry's fundamental base unit in the International System of Units (SI) used to measure the amount of substance. One mole is defined as about 6.022x10²³ particles such as atoms, molecules, ions, or electrons. This number is known as Avogadro's number.

Although we normally think of atoms being an electrically neutral substance, in chemistry, an atom is electrically neutral. The general ionization energy equation is $M(g) \rightarrow M^+(g) + e^-$ where M is the element. For example, $Na(g) \rightarrow Na^+(g) + e^-$ where Na is sodium. Sodium has a much higher 1st ionization energy requirement than most atoms.

Factors affecting ionization energy

- Nuclear charge:** The more protons in the nucleus and experience a much stronger attractive force on the electrons. Elements with higher energy levels are further away from the nucleus and experience a weaker attractive force. Ionization energy is inversely proportional to the number of energy levels.
- Shielding effect:** The more inner shells of electrons, the more they shield the outer electrons from the attractive force of the nucleus. This results in a weaker attractive force on the outer electrons.
- Atomic radius:** The more protons in the nucleus and experience a much stronger attractive force on the electrons. Elements with higher energy levels are further away from the nucleus and experience a weaker attractive force. Ionization energy is inversely proportional to the number of energy levels.

Ionization energy analogy

In order to remove an electron from an atom, you need to overcome the attractive force of the nucleus. The more protons in the nucleus, the more attractive force there is. The more inner shells of electrons, the more they shield the outer electrons from the attractive force of the nucleus. This results in a weaker attractive force on the outer electrons. The more protons in the nucleus and experience a much stronger attractive force on the electrons. Elements with higher energy levels are further away from the nucleus and experience a weaker attractive force. Ionization energy is inversely proportional to the number of energy levels.

1. What trend would you see going down a group? Explain your answer.

78 Calorimetry Investigation

Key Question: How can we generate and collect temperature change data in the school laboratory in order to calculate energy change and the enthalpy of reaction?

Using experimental data to calculate the enthalpy of reaction

- Calorimetry:** The science of measuring how much heat is gained or lost by a substance during a chemical reaction. Calorimetry is used to measure the enthalpy change of a reaction. A calorimeter is a device that is used to measure the heat change of a reaction. It consists of a reaction vessel surrounded by a water jacket. The temperature change in the water is measured and used to calculate the heat change of the reaction.
- Enthalpy:** The heat content of a system. It is a state function. The change in enthalpy, ΔH , is the heat change of a reaction at constant pressure. It is measured in kilojoules per mole (kJ mol⁻¹).
- Enthalpy of reaction:** The enthalpy change of a reaction. It is the difference between the enthalpy of the products and the enthalpy of the reactants. It is measured in kilojoules per mole (kJ mol⁻¹).

Investigation 5.3: Measuring energy changes using a calorimeter

Objective: To measure and calculate the enthalpy change of a reaction using a calorimeter.

Procedure:

- Set up the apparatus. Place the calorimeter in a beaker of water. Add the reactants to the calorimeter. Measure the temperature change in the water.
- Repeat the experiment. Measure and record the initial mass of the ethanol burner using the balance. Place the ethanol burner under the calorimeter.
- Conduct the experiment. Light the ethanol burner and allow it to heat the water in the calorimeter for the water gently with the stirring rod. Measure the temperature change in the water. Record the final mass of the ethanol burner. Calculate the heat released by the ethanol burner.
- Measure the final mass of the ethanol burner. Allow the burner to cool and then measure and record its final mass. Record the difference in mass (in grams).

Glossary

atom: The smallest particle of an element that can take part in a chemical reaction. It consists of a nucleus of protons and neutrons, surrounded by a cloud of electrons.

atomic number: The number of protons in the nucleus of an atom. It is denoted by the letter Z.

atomic mass: The mass of an atom, measured in atomic mass units (amu). It is the sum of the number of protons and neutrons in the nucleus.

atomic structure: The arrangement of protons, neutrons, and electrons in an atom.

atomic weight: The average atomic mass of an element, measured in atomic mass units (amu). It is the weighted average of the atomic masses of the isotopes of an element.

Avogadro's number: The number of particles in one mole of a substance. It is denoted by the letter N_A and is equal to 6.022 x 10²³.

Avogadro's law: The volume of a gas is directly proportional to the number of moles of gas, provided the temperature and pressure are constant.

Avogadro's hypothesis: Equal volumes of all gases, at the same temperature and pressure, contain an equal number of molecules.

Avogadro's constant: The number of particles in one mole of a substance. It is denoted by the letter N_A and is equal to 6.022 x 10²³.

Avogadro's constant (NA): The number of particles in one mole of a substance. It is denoted by the letter N_A and is equal to 6.022 x 10²³.

Avogadro's constant (NA): The number of particles in one mole of a substance. It is denoted by the letter N_A and is equal to 6.022 x 10²³.

Avogadro's constant (NA): The number of particles in one mole of a substance. It is denoted by the letter N_A and is equal to 6.022 x 10²³.

Link to skills icon: The blue margin link icon identifies where material is available in the Science Practices and Data Analysis chapter to support a particular math skill or science practice. Set these activities as a refresher before the students attempt the activity that requires the skill. Encourage students to refer to the support chapter often.

Collaboration icon: A group symbol indicates where students can work together. Group work provides opportunities for student collaboration and peer-to-peer support to explore and develop ideas. By speaking and listening to each other, communication skills and scientific vocabulary are extended.

Glossary: A glossary has been provided to help improve scientific literacy. Encourage students to refer to the glossary whenever they are unsure about the meaning of a key term. Key terms are identified by **bold blue text** the first time they appear in an activity. The are also listed in the chapter introductions.

Suggestions for Planning, Delivery, and Assessment

REMINDER: All teachers (whether using print or digital resources) can access the Teacher Toolkit materials on our digital platform BIOZONE WORLD (CG6). Use these to plan, deliver, and assess.



Lesson planning

- Refer to the **Teacher Notes** (in this guide) and the **Pacing Guide** in the Teacher Tool Kit to help with planning. These resources provide suggestions for pacing, delivering content, opportunities to support or extend students, and suggestions for assessment. Copy and paste the **Teacher Notes** into your planning documents to streamline lesson planning requirements.
- Add interest to your lessons by utilizing the resources in BIOZONE's **Resource Hub**. We have curated high quality resources to support the content of the activities. This saves you planning time as the resources automatically appear when you select an activity in BIOZONE WORLD. Use the resources as a way to introduce and prepare students for upcoming topics, or to consolidate understanding after lessons. Note: where there are **QR codes** on activity pages, these link directly to interactive 3D models and add interest to lessons.
- Use the coding in the Teacher's Edition to view where there are opportunities for extension (red flag), collaborations (group icon), practicals, or support for math and science practice skills (blue link icon). These provide ways to provide differentiated lessons.



Teaching

- Content delivery is flexible and can be adapted to suit your teaching plan and sequence. Depending on your students' prior knowledge and ability, the **Foundational Chemistry chapter** can serve as a refresher, an introduction, or a way to assess students' prior knowledge. The **Science Practices and Data Analysis chapter** isn't intended as a standalone unit, it's designed to be used as needed to support students' mathematical and scientific skills.
- The BIOZONE **Resource Hub** includes 3D models, videos, interactives, and websites, and allows you to introduce variety and engagement into your lessons. Select resources from the curated lists to introduce a topic, explore it in more depth, or wrap up a topic as needed.
- Switch up delivery by utilizing the **Presentation Slides** in our digital platform, BIOZONE WORLD. Students using the digital platform could be encouraged to use the slides to deliver the content themselves, providing an alternative way to engage students with the material.
- **Collaboration icons** identify opportunities for group work. Encourage peer-to-peer learning by assigning students to groups of mixed abilities when working in breakout groups or carrying out research. Alternatively, group students of similar abilities together so you can focus your attention on students needing targeted support.
- Enhance and extend students' scientific vocabulary by encouraging them to look up unfamiliar words in the **glossary** and encourage them to use the words as they navigate through the *Chemistry Explained* program. Words listed as key terms in the chapter front or written in blue bold on activity pages are defined in the glossary.
- Look to extend capable students by assigning them material from the worktext with a red flag in the margin of the Teacher's Edition. Some material on BIOZONE's **Resource Hub** is tagged as extension.



Assessment

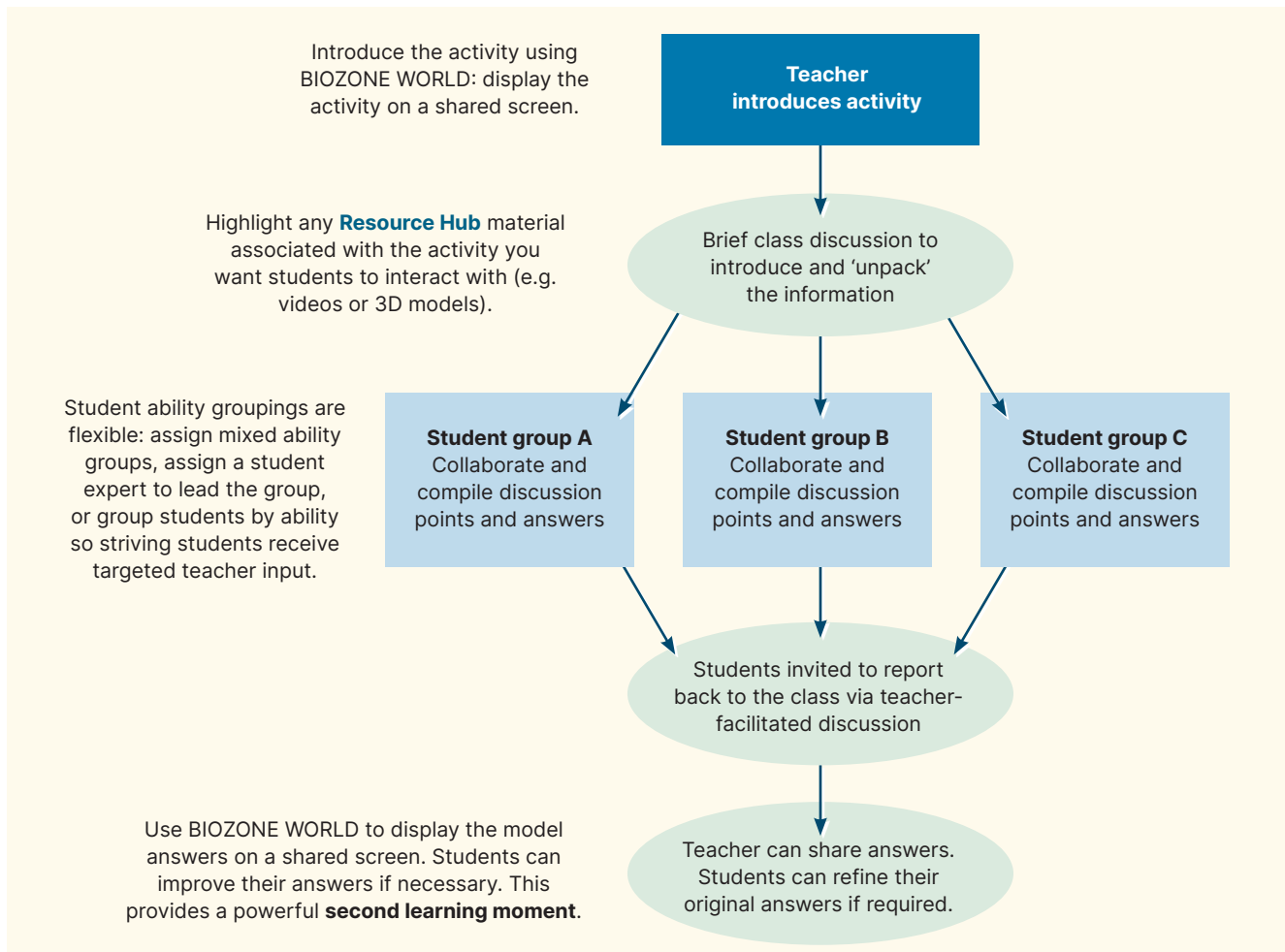
- Select activities to provide feedback (formative and summative) to students to update them on their progress. This can highlight areas of strength or areas needing work, or topics which students traditionally find difficult.
- Select activities as a formative assessment task to identify areas a student or the class needs to revisit before progressing to the next topic or chapter. Methods of formative assessment include reviewing student answers on selected activities or evaluating their contribution to discussions and group work.
- Use the end of chapter **Did You Get It? assessment tasks** to assess student understanding. This could be carried out as a test in class. Alternatively, you can set them as homework or open book assessments. If using as formative assessment, you may wish to use these tasks to identify if there are any gaps or misconceptions which still need to be addressed before moving on.
- Use the **Supplemental Assessment tasks** (download from the **Teacher Toolkit** in BIOZONE WORLD) as an "unseen" chapter assessment task. Students have no prior exposure to these assessments so they can be used as a formal testing moment.
- Two levels of **Test Banks** are available for differentiated testing and flexible delivery. Select questions for delivery at your discretion (e.g. end of activity, end of a learning sequence, or a more substantial end of topic test).

Teaching Strategies for Classroom Use

Achieving effective differential instruction in classes is a teaching challenge. Students naturally have mixed abilities, varying backgrounds in the subject, and different language skills. Used effectively, BIOZONE's worktexts and supporting resources can make teaching a mixed ability class easier. Here, we suggest some approaches for delivering content.

Making a start

Regardless of which activity you might be attempting in class, a short introduction to the task by the teacher is a useful orientation for all students. For collaborative work, the teacher can then divide the class into appropriate groups, with ability levels chosen at their discretion. Depending on the activity, the class may regroup at the end of the lesson for discussion or to present their findings, and you may choose to share model answers with the class for marking purposes.



The teacher introduces the topic. They provide structure to the session by providing background information and setting up discussion points and clear objectives. Collaboration is emphasized to encourage participation from the entire group. If necessary, students in a group can be assigned specific tasks.



Students work in small groups so that everyone's contribution is heard. They collaborate, share ideas, and engage in discourse. The emphasis is on sharing ideas, discussing questions, and formulating answers. Students may come up with additional questions and discussion points.



Students report back on their findings. Each student should have enough knowledge to report back on the group's findings. Reporting could consist of providing answers to questions, presenting a report, model, or slide show, or contributing to a debate. Students can revise their original answers, providing a powerful second learning moment.

Using collaboration to maximize learning outcomes

- The structure of *Chemistry Explained* allows for a flexible approach to delivering the content with your students.
- The content can be delivered in a way to support collaboration, where students work in groups to share ideas and information to gain a better understanding of a topic, carry out an investigation, or design a solution to a problem.
- By working together to ask questions and evaluate each other's ideas, students maximize their own and each other's learning opportunities. They are exposed to ideas and perspectives they may not have come up with on their own.
- Collaboration, listening to others, and voicing their own ideas is valuable for supporting English language learners to become confident in using English. It builds and develops English and scientific vocabularies in all students.
- Use a short, informal, collaborative learning session to encourage students to exchange ideas about the answer to a question.
- A collaboration icon (right) indicates where there is an opportunity for students to work together.



Peer to peer collaboration and support

- Peer-to-peer learning is emphasized throughout the worktext and is particularly valuable for challenging activities in which the content is more complex or the questions require students to draw on several areas of their knowledge to solve a problem.
- Stronger students can assist their peers and, in doing so, both groups benefit from verbalizing their ideas. Students for whom English is an additional language can ask their classmates to explain unfamiliar terms or ideas and this benefits the understanding of both parties.
- *Chemistry Explained* encourages students to think about, and share, what they already know and then build on this knowledge by exploring and explaining new content. This could be carried out in a more formal role. For example, assign groups to work together to complete an activity, to research questions, or design a solution to a problem.



Student A is capable. He helps to lead the discussion and records the discussion in a structured way.

Students B and C are also capable but less willing to lead discussion. They will add ideas to the discussion but need a little direction from A to do so.

Student D is less able but gains ideas and understanding from the discussion of students A, B, and C. She may add to the discussion as she gains confidence in the material being studied.

Extending students

Some students may require extension. We have tagged certain sections or questions in the Teacher's Edition with a red flag (right) in the margin to identify extension material. You can set these tasks for capable students, or all students can attempt them, but some students may require additional teacher or peer support to complete them.



We have also identified extension material on the BIOZONE [Resource Hub](#). A gifted and talented tag next to a resource indicates it is suitable extension material for students who may want to dive into the content in greater detail.

Reviewing work and providing answers

Our worktext approach encourages students to demonstrate their understanding of the content by inputting their answers on the activity page, either by writing it into the printed book or typing answers onto the digital version in BIOZONE WORLD. This approach makes it easy for students to record and share their answers and ideas with other students and their teacher. They can also review their own work or peer-review the work of others. Teachers can easily review an individual's work and see how they are progressing through the content. Model answers are provided for each activity and these can be shared with students at the teacher's discretion. Self reported grading is a powerful tool for accelerating learning and should be encouraged where possible. Students should also be encouraged to refine their answers (if needed) and deepen their level of understanding. This enhances the learning moment.



Peer feedback

Dividing students into small groups allows them to share their answers and ideas and receive immediate peer feedback. Sharing ideas and discussing alternative perspectives and solutions can broaden each student's understanding or perspective. Students may or may not come to a consensus answer through this process. Some students may wish to refine their original answer after the discussion.



Class discussion to review answers

Small groups can partake in collaborative summarizing when brought together as a larger group or class. Students can share ideas and answers through structured discussion, either as a class or within larger groups. The class benefits from hearing a range of ideas, and teachers can guide the discussion to ensure efficient use of time. At the end of the discussion, the teacher may wish to share the model answer with the class.



Review answers in class via BIOZONE WORLD

The teacher view in BIOZONE WORLD has model answers which can be toggled on and off using the show/hide buttons on an activity page. View activities in BIOZONE WORLD on a shared screen and reveal the answers as required. This is ideal for:

- Providing a concise model answer after a group or class discussion.
- Self marking by students. Students can amend their answer if necessary, providing a powerful secondary learning moment.
- Providing a quick review of answers if time is short.

Electronegativity: the tendency of an atom to attract bonding electrons from another atom.

Electron affinity: the energy change that occurs when an electron is accepted by an atom in the gaseous state to form an ion.

1. What is a periodic trend? A periodic trend refers to a predictable pattern or regular variation in the properties of elements across different periods and groups in the periodic table.
2. How can understanding periodic trends help predict the behavior of elements?
Understanding periodic trends helps predict the behavior of elements by allowing us to anticipate their reactivity, bonding tendencies, and other chemical properties based on their position in the periodic table.
3. Suggest why periodic trends occur in the periodic table: (Hint: consider what you already know about atomic structure)
Periodic trends in the periodic table occur due to the recurring patterns in atomic structure and electron configurations. As you move across a period, increasing nuclear charge pulls electrons closer, decreasing atomic radii, and increasing ionization energy and electronegativity. Moving down a group, additional electron shells increase the distance between the nucleus and outer electrons, which results in larger atomic and ionic radii, lower ionization energy, and decreased electronegativity. These trends allow for the prediction of element properties based on their position in the periodic table.

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Teacher review of student work

Students using the print version of *Chemistry Explained* write their answers directly into the space provided on the page. Teachers can revise or grade student responses as required.

Students using the digital version of *Chemistry Explained* input and submit their answers via the digital platform, BIOZONE WORLD. Teachers can revise or grade activities as required.

An Introduction to the Teacher's Notes

Teacher's notes are found on the following pages. These notes provide context for the material and additional detail for the learning points. Suggestions for differentiated instruction are provided, including ways to support striving learners and to extend capable students. Where appropriate, opportunities for developing literacy are identified. You can copy and paste this information into your own lesson plans to streamline planning.

Most activities are supported by material on BIOZONE's **Resource Hub**. The **Resource Hub** provides access to a large collection of free resources to supplement your teaching. They are identified with a hub icon on the first page of an activity. Where the resource is integral to the delivery of the activity, e.g. online data sets, computer simulations, or spreadsheets, we have indicated this in the teacher's notes.

Teacher's Notes

As you work through the Chemistry Explained content, use the resources in the Teacher Toolkit to plan and streamline your teaching. These include resources in BIOZONE's **Resource Hub**.

Chapter number and name

historical content boxes can be used as stimulus material for extension projects. Red flags in the margin of the Teacher's Edition indicate material is suitable to set as extension.

Chapter 1: Foundational Chemistry

In this chapter, the key focus is for students is to refresh their understanding of chemistry concepts typically covered in previous years. Students' prior knowledge of mixtures and solutions from earlier grades can now be applied to understand how different components can be separated based on their physical properties. Through hands-on experimentation with different laboratory practices, students can apply scientific investigation techniques. This chapter can be well supported with scientific practices from chapter 12. Ensuring that students have a firm understanding of these foundational concepts will support them as they then move through the BIOZONE chemistry program.

Activity 1: Defining Chemistry
This introductory activity helps students understand what chemistry is and its relevance to everyday life. Encourage students to brainstorm real-world applications of chemistry in groups. Consider having students create concept maps linking chemistry to daily experiences. If this activity is used as one of the first lessons in chemistry, it could be supported with additional introductory strategies such as class guidelines for success, what to expect, and a course preview.

Prior knowledge: use the "Prior Knowledge" sheet in the **Resource Hub** where students indicate the level of their foundational chemistry knowledge. You can use this information to prioritize what activities in chapter 1 are given emphasis, provided as homework, or left out.

Extension: researching careers in chemistry.

Activity 2: Choosing the Right Equipment
Use this activity to introduce or re-familiarizes students with common laboratory equipment. This provides an excellent orientation to common equipment and correct use. The videos provided on the **Resource Hub** could be viewed prior to the first laboratory session so students have some familiarity. You may wish to provide a laminated checklist of equipment for each station; you could build it off the equipment list provided in the appendix. Students can practice calibrating commonly used equipment. Use question 2 to reinforce the importance of this.

Activity 3: Safety in the Lab
Laboratory safety protocols should be introduced to all students, regardless of their prior experience in the lab. Teachers must cover the correct use of personal protective equipment (PPE), emergency procedures, the location of safety equipment, the meaning of safety signs, and how to identify potential hazards and respond appropriately, with guidance tailored to the specific lab environment.

Use the safety cartoon (page 6) and the interactive lab safety simulation on the **Resource Hub** **ways to engage students in a fun way.**

Scaffolding: use the print and cut "mix-and-match safety" activity

in the **Resource Hub** to link appropriate actions to measuring, heating, and weighing.

Extension: consider role-playing safety scenarios. Write scenarios of hazardous situations on cards: students can provide a sequenced list of appropriate responses or act it out (e.g. what to do for a chemical burn).

Activity 4: Classifying Matter
Definitions relating to matter, including elements, compounds, mixtures, and particle types are covered, providing an introduction to the states of matter. The simple investigation provides an easy way to view and compare the physical properties of solids, liquids, and gases. If you haven't already, consider including activity 165 "Observations and Inferences" from the Science Practices chapter with this investigation. Interactives in the **Resource Hub** allow students to visualize the states at a sub-microscopic level. If combining activities 5 and 6, you could incorporate demonstrations of state changes (e.g. ice, water, water vapor).

Extension: question 7 could be set as extension.

Activity 5: States of Matter
This activity could be combined with activity 6. Activity 5 explores solids, liquids, and gases. The simple investigation provides an easy way to view and compare the physical properties of solids, liquids, and gases. If you haven't already, consider including activity 165 "Observations and Inferences" from the Science Practices chapter with this investigation. Interactives in the **Resource Hub** allow students to visualize the states at a sub-microscopic level. If combining activities 5 and 6, you could incorporate demonstrations of state changes (e.g. ice, water, water vapor).

Activity 6: Changing States
Students investigate phase changes and latent heat through practical work. Teachers should provide guidance on obtaining accurate temperature measurement, graphing and interpretation as needed.

Scaffolding: use activity 169 to review graphing skills if needed.

can work in pairs to complete the quiz section of the video, which begins at 6:42.

Literacy: students could write their own diary entry and have a partner identify examples of chemical and physical changes. This provides an excellent way of connecting with students' own experiences.

Activity 8: Physical properties of Matter
Depending on the ability of your class, this activity could be delivered before activities 38-42 as a contextual introduction,

The **key focus** for the chapter is stated.

The activity is clearly identified for easy navigation.

Notes provide suggestions for what **prior knowledge** students should begin the topic with. This is followed with ideas for **scaffolding delivery** of the activity content, and providing **extension** material where applicable. Use this information to help deliver differentiated learning as required.

Suggestions for specific **literacy** opportunities are identified.

Your attention is drawn to materials on BIOZONE's **Resource Hub** when the resource is particularly useful for delivering or clarifying information.



Teacher's Notes

As you work through the Chemistry Explained content, use the resources in the Teacher Toolkit to plan and streamline your teaching. These include resources in BIOZONE's **Resource Hub** (such as videos, 3D models, and digital simulations), the Pacing Guide and Presentation Slides accessed via BIOZONE WORLD, and the Test Banks and additional assessment tasks. The content within the purple applications of chemistry boxes and yellow historical content boxes can be used as stimulus material for extension projects. Red flags in the margin of the Teacher's Edition indicate material is suitable to set as extension.

Chapter 1: Foundational Chemistry

In this chapter, the key focus is for students is to refresh their understanding of chemistry concepts typically covered in previous years. Students' prior knowledge of mixtures and solutions from earlier grades can now be applied to understand how different components can be separated based on their physical properties. Through hands-on experimentation with different laboratory practices, students can apply scientific investigation techniques. This chapter can be well supported with scientific practices from chapter 12. Ensuring that students have a firm understanding of these foundational concepts will support them as they then move through the BIOZONE chemistry program.

Activity 1: Defining Chemistry

This introductory activity helps students understand what chemistry is and its relevance to everyday life. Encourage students to brainstorm real-world applications of chemistry in groups. Consider having students create concept maps linking chemistry to daily experiences. If this activity is used as one of the first lessons in chemistry, it could be supported with additional introductory strategies such as class guidelines for success, what to expect, and a course preview.

Prior knowledge: use the "Prior Knowledge" sheet in the **Resource Hub** where students indicate the level of their foundational chemistry knowledge. You can use this information to prioritize what activities in chapter 1 are given emphasis, provided as homework, or left out.

Extension: researching careers in chemistry.

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Use this activity to introduce or re-familiarizes students with common laboratory equipment. This provides an excellent orientation to common equipment and correct use. The videos provided on the **Resource Hub** could be viewed prior to the first laboratory session so students have some familiarity. You may wish to provide a laminated checklist of equipment for each station; you could build it off the equipment list provided in the appendix. Students can practice calibrating commonly used equipment. Use question 2 to reinforce the importance of this.

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Laboratory safety protocols should be introduced to all students, regardless of their prior experience in the lab. Teachers must cover the correct use of personal protective equipment (PPE), emergency procedures, the location of safety equipment, the meaning of safety signs, and how to identify potential hazards and respond appropriately, with guidance tailored to the specific lab environment.

Use the safety cartoon (page 6) and the interactive lab safety simulation on the **Resource Hub** as ways to engage students in a fun way.

Scaffolding: use the print and cut "mix-and-match safety" activity

in the **Resource Hub** to link appropriate actions to measuring, heating, and weighing.

Extension: consider role-playing safety scenarios. Write scenarios of hazardous situations on cards: students can provide a sequenced list of appropriate responses or act it out (e.g. what to do for a chemical burn).

Activity 4: Classifying Matter

Definitions relating to matter, including elements, compounds, mixtures, and particle types are covered, providing an introduction to key terms and concepts. The simple investigation provides an opportunity to observe and understand chemical reactions, and provides an opportunity for students to develop and practice good laboratory practices. You may wish to refer to activity 165 "Observations and Inferences" from the Science Practices chapter in this investigation.

Scaffolding: if you have them, provide images showing examples of elements, compounds, or mixtures and have students classify them.

Extension: question 7 could be set as extension.

Activity 5: States of Matter

This activity could be combined with activity 6. Activity 5 explores solids, liquids, and gases. The simple investigation provides an easy way to view and compare the physical properties of solids, liquids, and gases. If you haven't already, consider including activity 165 "Observations and Inferences" from the Science Practices chapter with this investigation. Interactives in the **Resource Hub** allow students to visualize the states at a sub-microscopic level. If combining activities 5 and 6, you could incorporate demonstrations of state changes (e.g. ice, water, water vapor).

Activity 6: Changing States

Students investigate phase changes and latent heat through practical work. Teachers should provide guidance on obtaining accurate temperature measurement, graphing and interpretation as needed.

Scaffolding: use activity 169 to review graphing skills if needed.

Extension: question 5 can be set as extension.

Activity 7: Chemical and Physical Change

This activity supports students in identifying the differences between physical and chemical changes. A video linked in the **Resource Hub** demonstrates both types of changes. Students can work in pairs to complete the quiz section of the video, which begins at 6:42.

Literacy: students could write their own diary entry and have a partner identify examples of chemical and physical changes. This provides an excellent way of connecting with students' own experiences.

Activity 8: Physical properties of Matter

Depending on the ability of your class, this activity could be delivered before activities 38-42 as a contextual introduction, or simply used as a foundational introduction activity early on in the course. Students investigate properties of matter including density, conductivity, and hardness. Students could make predictions about properties before testing, and compare the results to their predictions.

Extension: if using in conjunction with activities 38-42, students could write a short explanation to explain their observation.

Activity 9: Mixtures

The intention of this activity is to introduce the concept of mixtures, and that mixtures can be homogeneous or heterogeneous. If possible, provide examples from the list in question 1 to use as visual representations to aid understanding.

Extension: you could deliver this activity as an introduction to activity 95 if desired.

Activity 10: Separating Mixtures

Students are introduced to practical separation techniques before designing an experiment to do their own separation (investigation 1.5). Taking the information provided within the activity and in the **Resource Hub**, students design a method to separate a mixture of gravel, iron, sand, and salt. Activity 164 provides support for planning a method and may be a useful companion activity. This activity could be carried out over two lessons: the first to plan, and the second to carry out the investigation. Alternatively, the planning segment could be set as homework.

Scaffolding: discuss the important features required in the method, including clear steps, selection of the correct equipment and technique, and identifying the physical property being used to separate the mixture.

Extension: students could research some real life applications of separating mixtures. For example, centrifugation of milk in the dairy industry to separate cream from milk, water treatment, or the purification of pharmaceuticals during manufacturing.

Activity 11: Paper Chromatography

This activity demonstrates separation through chromatography. Students separate ink components and gain an understanding of Rf values. Teachers should discuss real-world applications in forensics and research.

Scaffolding: set the calculating Rf values weblink on the **Resource Hub** for students needing support on Rf values.

Chapter 2: Atomic Structure and the Periodic Table

This chapter helps students review and build upon core chemistry concepts typically developed in earlier grades. They'll then apply their understanding to explore more complex atomic structures and the logical arrangement of the periodic table.

Activity 13: Introduction to the Atom

Depending on prior knowledge, this activity introduces or revises the fundamental concept of atoms. The key focus is for students to understand atoms as the basic unit of matter. Address common misconceptions in this topic. Students may believe that atoms are the smallest possible particles, so introduce the subatomic particles (protons, electrons, neutrons) to dispel this. Students may think the nucleus takes up most of the atom's space, so emphasize that atoms are mostly empty space.

Prior knowledge: students should have a basic grasp of elements and molecules. Use the video in the **Resource Hub** as introductory information to the topic.

Scaffolding: use physical models or the interactive model on the **Resource Hub** to provide visual support.

Literacy: create a word wall with key terms including "atom," "element," and "molecule" to build scientific literacy. Add to this as students move through the chapters. Students should use the glossary at the back of the book to define unfamiliar words.

Activity 14: Discovering Atomic Structure

Students explore the historical development of atomic theory. This provides an opportunity to discuss how scientific knowledge is a human endeavour, and knowledge develops through experimentation, observation and building on the findings of others. The concepts in this activity naturally mesh with activity 162, The Nature of Science. Students often think failed experiments are not useful but Rutherford's gold foil experiment results highlight that knowledge is obtained through trial and error;

it allowed others to build on it to obtain more accurate models.

Scaffolding: create a time-line of atomic discoveries on the classroom wall, adding to it as you progress through the unit.

Extension: students could research and present on a scientist mentioned in the text, explaining their contribution to atomic theory in more detail.

Literacy: implement a "jigsaw" reading activity where students become experts on one scientist, then teach others.

Activity 15: Atomic Structure

Students explore the current model of atomic structure, focusing on subatomic particles and their properties. Teachers should emphasize the importance of understanding atomic structure as a foundation for further chemistry concepts. Students frequently confuse atomic number and mass number. Stress that atomic number is the number of protons, while mass number is protons plus neutrons. Some think electrons contribute significantly to an atom's mass, so emphasize that electrons have negligible mass compared to protons and neutrons.

Prior knowledge: students should be familiar with the concept of positive and negative charges. They should also have a basic understanding of atoms as the building blocks of matter.

Scaffolding: use physical models or the simulations and models in the **Resource Hub** to visualize atomic structure. Use analogies, such as comparing an atom to a solar system, to help students grasp the concept of electrons orbiting the nucleus.

Extension: challenge students to create their own analogy for atomic structure. They should explain how their model represents key features of an atom.

Activity 16: Electron Configuration

This activity uses the Bohr model to demonstrate the configuration of electrons in atoms.

Scaffolding: use the apartment building analogy to explain electron configuration: each floor is an energy level, and apartments within those floors represent orbitals where electrons reside. This helps students visualize how electrons fill discrete energy levels. Use the periodic table to highlight the relationship between electron configuration and element position.

Extension: some students may be familiar with the SPD electron configuration method. They could compare this system with the Bohr system and note the similarities and differences.

Activity 17: Atomic Mass and Isotopes

The emphasis of this activity is the concept of isotopes and how they relate to atomic mass. Some students believe all isotopes of an element are equally abundant. Use the abundance of carbon isotopes on page 38 to show this is not the case. Some think isotopes of an element have different chemical properties. Stress that isotopes behave the same way chemically due to identical electron configurations.

Scaffolding: use a simple analogy, such as different-sized marbles to represent isotopes of an element. Students could create a visual representation of isotopes using colored balls or drawings to show the difference in neutron numbers.

Extension: the applications of chemistry example on page 39 provides examples of how isotopes are used in environmental science. Students could research other real-world applications of stable isotope analysis. For example, tracing animal migration and habitat use or to forensically trace pollution sources.

Activity 18: Development of the Periodic Table

Understanding the periodic table is a fundamental chemistry skill. Here, students explore the historical development of the periodic table. Discuss how many scientists contributed to its development and refinement over time. Students should understand how and why the periodic table was developed, and the difficulties encountered due to the lack of scientific knowledge at the time.

Scaffolding: use the information provided and in the **Resource Hub** to create a time-line of periodic table development. Use an online time-line maker or draw it on a large piece of paper.

Extension: students research alternative periodic table designs and compare to the one commonly used in chemistry today.

Activity 19: The Modern Periodic Table

This activity unpacks the organization of the modern periodic table. Encourage students to refer to the periodic table often, especially when linking an element or element group's properties with its position on the periodic table. A reference periodic table, including atomic mass and mass number, is provided on the back cover for print users and within the BIOZONE WORLD platform for digital users. This table includes the states of elements at room temperature, and can be referred to when using equations and formulae in the following chapters. Some students think all elements on the periodic table occur naturally. Highlight the synthetic elements.

Scaffolding: assign sharing groups where each member researches the properties and examples of metals, semi-metals, or non-metals. The class reconvenes to share and compare findings.

Activity 20: A Closer Look at Element Groups

The activity encourages students to become familiar with the properties of key element groups. It will benefit students to be familiar with these groups, where they are located on the periodic table, and their key features because they are referred to in subsequent chapters. Students could make additional notes on the groups without an information panel. Alternatively, place a large periodic table on the wall and have students create information panels which they can link with string to the relevant areas on the periodic table. Students often think elements in the same group have similar atomic masses. Clarify that group elements share similar electron configurations, not necessarily masses. Students frequently assume all metals are solid at room temperature, mention mercury as a liquid metal as an exception. Many think all gases are in Group 18 (noble gases), so clarify that other groups also contain gaseous elements (e.g. hydrogen, nitrogen, oxygen).

Extension: question 3 provides an extension research activity.

Activity 21: Periodic Trends

This activity focuses on understanding trends in the periodic table, including atomic radius, ionization energy, and electronegativity. In previous years, students may have looked at trends in metallic properties or reactivity but at this level, the trends are related to the structure of the atom, specifically the nuclear charge due to atomic number, and electron-electron repulsion due to the electron configuration. The focus is on trends across and down the periodic table, and all supporting data is provided rather than students being required to memorize it. Many students believe electronegativity and electron affinity are the same. Clarify the distinction between these concepts. Many believe all trends in the periodic table are smooth and unbroken. Emphasize that there are often exceptions and irregularities.

Prior knowledge: students should be familiar with the basic structure of the periodic table and electron configuration.

Extension: students could research and present on "exception elements" that don't follow general periodic trends, explaining why these exceptions occur. Question 3 is an extension task.

Literacy: introduce terms such as "atomic radius," "ionization energy," and "electronegativity." Have students create flashcards with definitions and examples for each trend.

Activity 22: Atomic and Ionic Radii

This activity explores trends in atomic and ionic radius across the periodic table. The key focus is on understanding how and why atomic radius changes across periods and down groups. Students could practice drawing the electron configuration of atoms and their ions across period 3 (K, Ca, Al, P, S, Cl) as reinforcement. Some students may have a misconception that the more electrons in the valence shell, the larger the atom radius. Emphasize that two forces, nuclear attraction and electron-electron repulsion, both operate and the resulting NET force is the main determinant of atomic radius.

Prior knowledge: structure of the periodic table, basic atomic structure, and ion formation.

Scaffolding: use the presentation slides, or visual aids to illustrate atomic radius trends. Ensure students understand the trend in atomic radius before introducing the comparison with the ion radius. Make a clear distinction between cation and anion changes. Refer to the "how to guide" steps to help students compare the radii of atoms and ions. Students can reference activity 169 for graphing support if needed.

Extension: students predict atomic radii of elements not shown on trend graphs. Question 6 can be set as extension.

Literacy: practice using terms including "shielding effect", "electron-electron repulsion", and "effective nuclear charge."

Activity 23: 1st Ionization Energy

This activity focuses on trends in 1st ionization energy across the periodic table. The key focus is on understanding how ionization energy changes across periods and down groups. Begin with practising ionization equations. Students will be familiar with metal ionization, but non-metal ionization (i.e. Cl^+) will seem counter-intuitive. Link unlikelihood of a non-metal cation to the high 1st ionization energy required. Students must also understand the relationship between ionization energy and atomic radius. Explain why we use the term "mole" in chemistry. Discuss the competing factors of nuclear charge and shielding.

Scaffolding: use energy level diagrams to explain ionization energy. Ensure students can define the term and work through the "how to" on the board.

Extension: students consider 2nd and 3rd ionization energies. Emphasize the relationship between ionization energy and electron configuration. Question 3 can be set as extension.

Activity 24: Electronegativity

Electronegativity trends in the periodic table are explored. Students must understand the relationship between atomic radii and how close two atoms can get to each other.

Scaffolding: most students can focus on the trends and leave the bonding continuum until they reach the next chapter.

Extension: material at the top of page 55 is more advanced, it can be set as extension or provided to all students with teacher guidance. Capable students can progress to predicting bond types based on electronegativity differences in activity 32.

Chapter 3: Bonding and Substances

The key focus is to investigate molecules by representing them using Lewis structures, determining their molecular geometry, and therefore their polarity. The three key types of intermolecular forces between particles in molecular substances are also examined. Students investigate groups of substances at the submicroscopic level, including bonding type and particles involved, and relate these to physical properties of the substances at macroscopic level.

Activity 26: Types of Chemical Bonds

This introductory activity can be used as an anchoring phenomenon for students to start thinking about the types of bonding and particles involved in different substances. The focus is on describing the differences between metallic, ionic, and covalent bonding.

Prior knowledge: students should be familiar with basic atomic structure, including protons, neutrons, and electrons. **Scaffolding:** the video on the [Resource Hub](#) can be used to introduce the topic. Use visual aids such as diagrams and models to illustrate the different types of bonding. Compare bonding to different types of relationships (e.g. sharing in covalent bonds vs giving and taking in ionic bonds).

Extension: students could research real-world examples of materials with each type of bonding and present their findings.

Literacy: introduce key terms such as "ionic," "covalent," and "metallic" bonds. Students should use the glossary to define them

and use the terms in their explanations.

Activity 27: Ionic Bonding

This activity uses diagrammatic models to explain ionic bonding; it can be used as preparation for writing formulae for ionic compounds. Ion charts are provided on page 61. Discuss which ions (formula and charge) will be provided to students in any future examinations.

Scaffolding: students can prepare flip cards with the name of the ion on one side and the formula on the other. They could test each other in pairs to recall these common ions.

Extension: students could add additional ions to the charts on page 61. They can look throughout the book to identify which other ions are used in other chapters.

Literacy: link the suffix of anions to the presence of oxygen (-ate) or not (-ide).

Activity 28: Writing Ionic Compound Formulae

This activity provides an introduction to writing formulae for ionic compounds. Two different methods are provided: the cross-and-drop and the visual method. Students may find it easier to start with the visual method.

Prior Knowledge: students should understand electron transfer and the formation of ions. It is important that they can recognize ionic compounds by the presence of a metal cation and non-metal anion transferring electrons.

Scaffolding: provide step-by-step instructions for using the ion cards and for using the cross-and-drop method for writing ionic formulae.

Extension: challenge students to write formulae for more complex ionic compounds, e.g. those with polyatomic ions.

Literacy: emphasize the correct use of chemical symbols and notation in writing formulae.

Activity 29: Covalent Bonding

This activity focuses on using diagrammatic models to explain covalent bonding and the concept of polar bonds. Establish the difference between ionic and covalent bonds, emphasizing that covalent bonding is sharing electrons between non-metal atoms. The **Resource Hub** has interactive molecule building programs to support the concept of visible atoms and the relationship to formula.

Scaffolding: use the analogy of sharing toys to explain electron sharing in covalent bonds. Provide examples of polar and non-polar molecules, reminding students of the concept of electronegativity from activity 24.

Extension: covalent bond overlap is an extension concept. Students may wish to research a deeper understanding of the cause of this phenomenon.

Activity 30: Lewis Structures

This activity involves drawing Lewis structures and explaining their usefulness. Students must be able to gather data from a periodic table, using information from the group number to infer valence electron number. Emphasize checking calculations at each stage and ensuring that the electron pair number is even before they start to draw the Lewis structure. Students could use crosses instead of a dot if it makes it easier to see electrons. Ensure students understand that a line represents 2 electrons (a pair). Students may forget to include lone pairs in Lewis structures. Emphasize the importance of showing all valence electrons.

Scaffolding: start with simple molecules and gradually increase complexity. Use color-coding to differentiate between bonding and non-bonding pairs. Teachers may need to 'walk-through' the steps involved in drawing a Lewis structure for more than one example.

Extension: ask students to draw Lewis structures for molecules with expanded octets, central atoms with only 2 or 3 valence electron pairs, or complex ions, remembering to add or subtract electrons in the initial step.

Activity 31: Molecular Geometry

This activity explains the meaning of VSEPR theory and how it is used to predict molecular shapes. Students may forget that lone pairs affect molecular geometry. It is important to emphasize that both bonding and non-bonding regions of electron density are responsible for the base geometry, and hence the approximate bond angle, while only bonding pairs are responsible for the final shape.

Scaffolding: some students may benefit from a chart of common molecular geometries or add to the diagram in activity 31. For some learners, pattern seeking may embed the concept more clearly.

Extension: have students predict the shapes of more complex molecules and compare their predictions with actual data.

Emphasize that although we have laws and 'rules' in chemistry, often, exceptions occur. Extension students should be able to explore rationale for these exceptions.

Literacy: for some terms, such as electron density, a number of different terms are used, e.g. regions, clouds, pairs. Students could add the different terms to their glossaries but be advised that a consistent term should be used throughout their work and answers. This activity provides a structured breakdown of steps (a "how to") to answering a long-form question on comparison. Teachers can provide a selection of molecules from the activity for students to practice their sentence structuring.

Activity 32: Bond Polarity

This activity describes why polar and non-polar bonds arise and uses the Pauling scale to determine electronegativity. Students have already been introduced to the difference in covalent and ionic bonding in activity 24 and the relationship to electronegativity, but teachers may want to start the lesson with a revision of this concept. Clarify the difference between bond polarity and molecular polarity to prevent confusion.

Prior knowledge: students should understand the concept of electronegativity and how it affects electron distribution.

Scaffolding: use visual aids to show how electronegativity differences lead to bond polarity. Ensure the students embed the bond polarity concept before they move onto molecule polarity.

Activity 33: Molecular Polarity

This activity examines the factors that determine whether a molecule is polar or non-polar. A misconception may arise where students classify ionic substances as polar. Emphasize that the focus on Lewis structures, geometry, polarity, and intermolecular forces only concerns molecules in this course.

Scaffolding: a flow chart, such as the one provided in the **Resource Hub** can be used as a reference for students so they consider the relevant variables when identifying the molecule.

Literacy: teachers can select two or more additional molecule examples for students to practice their long-form answers using the "how to guide" for scaffolding.

Activity 34: Intermolecular Forces

This focus of this activity is to familiarize students with the descriptions and names of the different types of intermolecular forces. It can be used as introduction before the intermolecular forces are examined in depth. Consider beginning with group discussions on why some substances are found as gases at room temperature and link to the types of attraction between the particles. Use the interactive resource in the **Resource Hub** to initiate or summarize the discussions as needed. Emphasize the difference between intermolecular and intra-molecular. Some students may have the misconception that the covalent bonds within a molecule break when a substance melts or boils. Ensure they understand that breaking these bonds is a chemical reaction rather than the physical reaction of breaking intermolecular bonds in a substance in a change of state (which is reversible).

Prior knowledge: students should know about molecular polarity and basic molecular interactions.

Extension: have students predict the physical properties of substances based on their intermolecular forces.

Activity 35: London Dispersion Forces

This task emphasizes how London dispersion forces arise and their effect on melting and boiling points. Students may forget that London dispersion forces are present in all molecules. It is important to establish that all molecules and atoms have temporary or instantaneous dipoles due to the random ‘condensing’ of moving electrons. These then lead to London dispersion forces due to induced dipoles when one or more molecule or atom comes within ‘range’.

Scaffolding: ask students to use the interactives in the **Resource Hub** in combination with the activity content.

Extension: students could research and explain why some period 2 hydrogen compounds do not follow the trend of low boiling point and low molar mass. Students could practice drawing Lewis structures to illustrate the phenomenon. Discuss how macroscopic, sub-microscopic, and symbolic representations can sometimes be combined to explain a phenomenon.

Activity 36: Permanent Dipole-Dipole Bonding

The term ‘dipole-dipole interactions’ is often used interchangeably with permanent dipole-dipole bonding.

It refers to the interactions between molecules that have permanent dipoles, where the positive end of one molecule is attracted to the negative end of another molecule. Ensure the students understand that dipoles are a feature of polar molecules, while interactions, forces, or bonding occurs because two or more molecules interact. Remind students that this dipole-dipole force is in addition to London dispersion forces, and that although typically stronger, it may not always be in greater molar mass molecules. Also, monatomic atoms, such as inert gases, e.g. xenon, cannot exhibit this type of bonding, as more than one type of atom (a compound) needs to be bonded in order for a dipole to exist.

Activity 37: Hydrogen Bonding

Students explore the unique properties of substances with hydrogen bonding and how it affects their physical properties. A common misconception arises where students think any molecule containing hydrogen has this type of bonding, such as methane (CH_4), but it must be reinforced that the H is bonded to N, O, or F, and caused due to the large electronegative difference between atoms.

Prior knowledge: students should understand the concept of dipole-dipole interactions and the unique properties of water.

Scaffolding: use the interactive water molecule models in the **Resource Hub** to show hydrogen bonding.

Extension: students can research the role of hydrogen bonding in biological systems and present their findings. They can also attempt activity 94 on water’s properties to start linking concepts throughout this course.

Literacy: assess students against the keywords used in this chapter by matching or writing definitions. Students can compare their definitions against those in the glossary.

Activity 38: Types of Solid Substances

This activity describes different types of solids in terms of bonding between atoms/molecules. Previously, students covered physical properties of different substances. At this level, it is important that the sub-microscopic structure of the substances, both particles and bonding, are well understood and linked to all physical properties. The substances will mostly be examined in their solid states, although some properties are only apparent in some substances, such as conductivity, when in liquid state. In gaseous state, for most substances, the properties discussed do not apply. The behaviour of gases is covered in chapter 8.

Prior knowledge: students should be able to distinguish between the basic types of bonding.

Scaffolding: use diagrams to illustrate molecular, ionic, metallic, and covalent network solids. Provide a list of examples of each type on the board: students can put them into their appropriate solid classification.

Activity 39: Molecular Solids

Students need to be familiar with the concepts of physical properties of substances including solubility, conductivity, melting point and boiling point, and ductility and malleability. Teachers may wish to combine this section with activity 8 in the foundational chemistry chapter, or refer back to it if already covered. Videos from the **Resource Hub** could be set as a ‘flipped learning’ homework task before each lesson on the substances.

Refer students to activity 164, ‘Investigations in Chemistry’ in the science practices chapter before they write their method for investigation 3.3. Students could write it as a group and collectively critique and edit it. Alternatively, students could swap their method with another student and test how well the method works by following the instructions.

Activity 40: Metallic Solids

The relationship between the structure and bonding of metallic solids and their physical properties are described. Alloys are also introduced as an application and this could be extended if time permits. The formation of alloy bells is presented in ‘hunting the elements’ video in the **Resource Hub**.

Prior knowledge: students should be able to identify metals and understand the basic properties of metals. They can refer back to activities 19 & 20 to refresh their memory.

Scaffolding: use models to illustrate the ‘sea of electrons’ in metallic bonding. Compare the properties of metals to those of ionic and covalent solids.

Extension: students can investigate the properties of various metal alloys and their applications.

Literacy: emphasize the correct use of terms, ‘metallic bonding,’ ‘ductility,’ ‘malleability,’ and ‘conductivity.’

Activity 41: Ionic Solids

This activity explains why ionic solids form lattice structures and relates their structure to their physical properties. Students may forget that ionic bonds are directional. Emphasize the importance of electrostatic attraction in forming lattice structures.

Prior knowledge: students should understand ionic bonding and the formation of ions.

Scaffolding: use 3D models (e.g. in the **Resource Hub**) to demonstrate the lattice structure of ionic solids. Provide examples of common ionic compounds and their properties

Extension: have students research the solubility and conductivity of various ionic compounds in different solvents. Link to activities 51 & 97.

Activity 42: Covalent Networks

This activity describes the different forms and properties of carbon in terms of covalent bonds and uses for different carbon structures.

Scaffolding: use diagrams to compare the structures of diamond, graphite, and other carbon allotropes. Discuss the unique properties of each form.

Extension: students research applications of carbon nanotubes and graphene in modern technology in more detail.

Literacy: once students have completed the chart in question 20 of activity 43 they could review and extend their answers into long-form paragraphs to compare the bonding and structure of any two substances relating to a physical property.

Chapter 4: Chemical Reactions and Stoichiometry

The key focus is to investigate chemical reactions and stoichiometry by understanding the types of reactions, conservation of mass, and the concept of the mole. Students examine the stoichiometric relationships between reactants and products, including calculating expected yields and percentage yields. Gravimetric analysis techniques are explored,

including determining water of crystallization in compounds. Students investigate various types of chemical reactions at the submicroscopic level, including synthesis, decomposition, and replacement reactions, and relate these to the physical properties and practical applications of substances.

Activities 44 & 45: Chemical Equations and Balancing Equations

These activities focus on teaching students how to write and balance chemical equations. Refer back to this content when required. Students may think coefficients can be fractions. Emphasize whole number coefficients only (the exception being combustion equations and enthalpy of formation equations in the next chapter). Some struggle with polyatomic ions remaining intact. Reinforce that these stay together when balancing.

Prior knowledge: students should be familiar with the periodic table, chemical symbols, and basic chemical reactions.

Scaffolding: intersperse the analogy of a balanced scale (page 102) with questions and discussion to explain the concept of balancing equations. To foster skills in balancing simple equations, use the “how to guide” and work through some examples as a class before having students work independently. Identify the simple equations to balance before moving on to more complex ones. Refer to a periodic table to help students identify elements and their symbols.

Activity 46: Classifying Chemical Reactions

The focus is on identifying and classifying different types of chemical reactions. Students often misclassify reactions based on superficial features. Practice identifying key characteristics of each type to prevent this. Students may confuse single and double replacement reactions, so highlight the difference in number of elements/compounds exchanged to clarify.

Scaffolding: use visual aids such as reaction diagrams and flowcharts to help students categorize reactions. Provide examples of each type of reaction and practice classifying them. Different colored plastic building blocks can be useful to demonstrate the making and breaking of bonds in different chemical reactions.

Extension: students can investigate real-world applications of different types of reactions, such as combustion in engines or synthesis in pharmaceutical manufacture.

Literacy: encourage students to use precise language when describing reactions. Provide sentence starters for classifying reactions, such as “This reaction is a synthesis reaction because...”

Activity 47: Synthesis Reactions

The synthesis reactions are also known as combination reactions, where typically two reactants form one product.

Scaffolding: before asking the students to balance the equations in question 1, identify which class each falls under. Classify them under the general formula for oxide, halide, metal oxide and water. Students will then be able to anticipate the expected products.

Activity 48: Decomposition Reactions

Consider delivering this activity with activity 47 (synthesis reactions) so students can compare and contrast the reactions. Emphasizing the conservation of mass, explain to students why energy, heat, or electricity is written above the arrow rather than as a reactant. Decomposition using heat is also called thermal decomposition. Teachers could provide more equations for additional practice.

Activity 49: Replacement Reactions

It is important for students to distinguish between single and double replacement reactions. Precipitation is covered in more detail in activity 51, but students will also require understanding of this reaction when covering observations in equilibrium reactions and with solubility and solutions. Neutralization is introduced and is covered in more detail in the acid-base reactions (activity 109).

Scaffolding: students can use the ion cards from activity 28 to help them develop the formula for any metal salts.

Activity 50: Investigating Reactions

Investigation 4.1 helps students identify synthesis, decomposition, and replacement reactions. For an alternative delivery, this activity could be completed before activities 47-49; each of the follow-up questions could then be completed as activities 47-49 are completed.

Activities 51 & 52: Precipitation and Precipitation Reactions

These activities focus on performing and observing precipitation reactions to understand the formation of insoluble compounds. Students often think all products in aqueous reactions precipitate, therefore reinforce solubility rules and spectator ions. Many forget to consider ion dissociation when writing net ionic equations. Emphasize complete dissociation of strong electrolytes. For expediency, groups could carry out one of the reactions in investigation 4.2, and look at the results of other students to complete the table.

Scaffolding: use photos, the videos on the [Resource Hub](#), or a simple demonstration to introduce the topic. Students can use a solubility grid, where each cation and anion of a reactant combine to form two salts. Remind students that one or neither product may be insoluble. Next to the name of the products, students can note whether they are soluble or insoluble, identify the rule used, and then write the formula for the products.

Extension: students may explore applications of precipitation reactions in limescale buildup (page 112) in more detail.

Activity 53: The Mole

Students develop understanding of the mole as a quantity in chemistry and practice converting between moles, mass, and number of particles to solidify understanding. If required reference the Working With Numbers activity 168 in the science practices chapter for background. Students may think a mole is always 6.022×10^{23} particles. Emphasize the role of molar mass as a conversion factor. Clarify it can be atoms, molecules, or formula units.

Prior knowledge: students should be familiar with basic counting and measurement concepts.

Scaffolding: use question 4 to springboard into why a mole is used rather than a count of particles.

Extension: some students may explore the historical development of the mole concept and its significance in modern chemistry.

Activity 54: Relative Mass

This activity focuses on explaining and calculating relative atomic and molecular masses. This concept is introduced in activity 17 and provides an opportunity for students to start or add to their own concept map. The map can be built up as students work through the course.

Extension: some students may research how relative atomic masses are determined experimentally and their importance in scientific research.

Literacy: ensure students understand the difference between similar but different concepts: relative atomic mass (A_r) which is a dimensionless quantity that compares the mass of an atom to the atomic mass constant; relative molecular mass (M_r), similar to A_r but applies to molecules; and molar mass (M), which is the mass of one mole of a substance expressed in grams per mole (g/mol), providing a direct link to the quantity of substance in moles.

Activity 55: Molar Mass

Students use both symbolic and macroscopic representations of moles for substances. Link the mass of each mole to the structure of the atoms involved, reminding students that the mass is directly related to the number of sub-atomic particles in each atom. Students also need to understand that chemical equations are represented as moles which becomes relevant with stoichiometry and then thermochemical equations in the next chapter.

Activity 56 & 57: Using Molar Mass and More Mole Calculations

These activities focus on using the relationship between moles, molar mass, and mass to perform calculations. Begin the lesson by

revising fact family triangles (activity 168) to familiarize students with practice in rearranging and using triangles. The periodic table (inside back cover or on BIOZONE WORLD for digital users) can be used for molar mass data, although students may wish to develop a list of common compounds, i.e. CO_2 , and write the molar mass beside each for easy reference. The calculations in activity 57 can be set as homework to reinforce skills. Encourage systematic approaches so students include all atoms in a formula when calculating molar mass. Encourage systematic approaches. Many mis-handle polyatomic ions in compounds; reinforce that these are treated as units in molar mass calculations.

Prior knowledge: students should understand the concept of the mole and be able to calculate molar mass.

Scaffolding: provide a formula triangle ($n = m \div M$) to help students remember the relationship. Use guided practice with simple examples and the “how to guide” before moving to more complex problems.

Literacy: emphasize the correct use of units in calculations.

Activity 58: Empirical and Molecular Formulae

This activity focuses on explaining and determining empirical and molecular formulae, and is reinforced by determining the empirical formula of copper oxide through a laboratory experiment. Students may think empirical and molecular formulae are always different. Show examples where they can be the same. Some struggle with converting between the two so providing practice problems going both directions can help.

Prior knowledge: students should understand basic chemical formulae and the concept of moles.

Scaffolding: use visual aids such as molecular models to show the difference between empirical and molecular formulae. Continue with step-by-step examples of determining each type of formula until the students can work independently.

Extension: some students may investigate how empirical and molecular formulae are used in chemical analysis and research.

Literacy: provide sentence starters for explaining the difference between empirical and molecular formulae. Encourage students to write out their calculations and reasoning.

Activity 59: Percentage Composition

The main focus is on calculating the percentage composition of elements in compounds. A practical investigation supports the skill. Explain the importance of zeroing the scales before the experiment, and ensuring the reading is stable when the value is recorded. Students often confuse percentage composition with empirical formula ratios. Clarify the difference between mass and mole ratios. Ensure students convert all masses to the same unit before calculating percentages. Emphasize consistent units.

Prior knowledge: students should understand basic arithmetic and the concept of mass.

Scaffolding: use visual aids such as pie charts to represent percentage compositions. Encourage students to reference the “how to guide” for calculating percentage compositions as often as needed to gain confidence. The tutorial video in the **Resource Hub** provides additional support.

Extension: some students could complete the first page independently.

Activity 60: Stoichiometry and Mole Ratios

This activity focuses on using stoichiometry to calculate the yield of products in a chemical reaction. Simple mathematical knowledge of ratios is required but a visual representation using molecular models may help to demonstrate that as one substance increases, then all substances increase (or decrease) at the same ratio.

Prior knowledge: students should understand the concept of moles and be able to balance chemical equations.

Scaffolding: use the ‘how to guide’ as a worked example in front of the class. The next few problems can also be demonstrated, but

stop at each step for the students to calculate and conform their answer. Finally, set problems for independent work.

Activity 61: Stoichiometric Problems

This activity build on the previous activity by adding an additional step of converting mass and moles. Refer students to the fact family triangle in activity 56 for support. To generate more practice questions, edit the provided questions by altering the amount of starting mass and choosing different reactants or products. Although the conversions in this activity are between reactants and products, the process will work for any two substances in the equations.

Scaffolding: some of the questions require balanced equations to be written by the students before calculating the mole ratio. If needed, you can provide the equations or work through them on the board.

Activity 62: Gravimetric Analysis 1: Water of Crystallization

A laboratory experiment is used to demonstrate that water of crystallization can be calculated in hydrated copper sulfate. Discuss as a class the process of dehydrating the salt and why at least two weighings is important to achieve a dehydrated salt. Students may think all water loss in hydrates is water of crystallization. Discuss possibility of adsorbed water.

Scaffolding: break question two in steps so students don't feel so overwhelmed with the calculations required.

Activity 63: Gravimetric Analysis 2: Analysis of a Reaction

This activity focuses involves performing a gravimetric analysis to determine the amount of a substance in a sample. Review the process of precipitation from activity 51. Discuss the importance of using balanced equations in stoichiometry.

Prior knowledge: students should understand the concept of moles and be able to balance chemical equations.

Literacy: emphasize the correct use of terms such as gravimetric analysis and precipitate. Use question two as practice for writing laboratory methods correctly.

Activity 64: Limiting Reactants

This activity focuses on explaining the concept of limiting reactants and how they affect chemical reactions. They should also be able to calculate percentage yield. Students may think limiting reactant is always the one with fewer moles. Demonstrate cases where stoichiometric ratios matter.

Scaffolding: use visual aids such as diagrams showing reactants and products in the class introduction. Provide examples of reactions with limiting reactants and practice identifying them.

Extension: some students may investigate the importance of limiting reactants in industrial processes and research.

Chapter 5: Thermochemistry

The key focus is to investigate thermochemistry by understanding the energy changes in chemical reactions, including the concepts of enthalpy, entropy, and specific heat capacity. Students examine thermochemical equations and stoichiometry to calculate enthalpy changes in reactions, using mole ratios and energy changes. Calorimetry techniques are explored to measure heat changes during chemical reactions, and Hess's Law is applied to determine enthalpy changes through different reaction pathways. The chapter also covers the role of energy in phase changes and the calculation of energy requirements for these transformations.

Activity 66: Energy in Chemistry

The fundamental concept of energy in chemical reactions is introduced. The key points to emphasize are the role of energy in controlling matter interactions and changes, explanation of enthalpy and its importance, and the differences between exothermic and endothermic reactions. It is important to establish

the definitions of kinetic and potential energy in a chemistry context as students may only be familiar with the physics definition. This concept of transformation between the two forms of energy can be supported with the interactive in the **Resource Hub**.

Prior knowledge: understand potential and kinetic energy and the difference between them.

Scaffolding: use visual aids or animations to illustrate energy changes in reactions. Encourage students to provide real-world examples of each type of reaction.

Activity 67: Heat, Energy, and Temperature

The main focus of this activity is distinguishing between heat, energy, and temperature. Students may have a misconception that heat and temperature are interchangeable terms, especially as weather is often described as hot or cold, so address this early. Use analogies to help students understand the differences (e.g. temperature as speed of particles). Teachers need to emphasize: 1) the definition of temperature as a measure of average kinetic energy, 2) the differences between heat and energy, and 3) introduce the three main temperature scales: Celsius, Fahrenheit, and Kelvin. Provide practice in converting between temperature scales. Discuss why Kelvin is important in scientific calculations.

Activity 68: Thermodynamic laws and Thermochemistry

This activity introduces the laws of thermodynamics and their application in chemistry. After explaining the thermodynamic laws, make sure the students can summarize them as follows:

First Law of Thermodynamics (conservation of energy); Second Law of Thermodynamics (increasing entropy); Third Law of Thermodynamics (absolute zero); Zeroth Law of Thermodynamics (thermal equilibrium).

Use real-world examples to illustrate each law and discuss the implications of these laws in chemical reactions and everyday life. This could be used as a group brainstorming activity before sharing ideas as a class. A common misconception is that 'cold' travels, e.g. coldness from a piece of ice travels to the hand. Emphasize, using the thermodynamic laws, that transfer of heat is in one direction only, but this is not to be confused with systems 'removing' heat for an endothermic process, such as bond breaking in ice melting, where the heat is transformed or 'used'. Students can confuse heat transfer and heat energy transformation, so ensure this distinction is secure.

Scaffolding: this activity is information heavy, and probably introduces many new concepts to students. Break it down by having students make a table of the information, adding a column for real-world examples and build from there.

Extension: students could use question 5 as an assessment opportunity to develop a more formal report.

Activity 69: Entropy

The concept of entropy and its role in chemical reactions is explored. Key points to cover are the definition of entropy as a measure of disorder and the factors that increase (or decrease) entropy in a system. Use visual aids to demonstrate increasing disorder (e.g. cards or marbles). Discuss everyday examples of increasing entropy and relate entropy back to the Second Law of Thermodynamics.

Prior knowledge: a good understanding of the laws of thermodynamics.

Extension: the relationship between entropy and spontaneous reactions can be used as an extension topic.

Activity 70: Enthalpy

This activity focuses on enthalpy and its role in chemical reactions. Students must understand that enthalpy is the heat content of a system. Review exothermic and endothermic reactions and the relationship between bond breaking, bond forming, and enthalpy changes. Students can create a list of exothermic and endothermic examples which can then be checked against the list in the next activity. Combustion and photosynthesis are used as examples, and these two processes are used as a context in other activities so students can refer back to this activity if required.

Link the process of breaking bonds as an endothermic reaction back to covalent bonding and what force needs to be overcome. Highlight the symbols used (H) and the -ve or +ve signs to a decrease or increase in enthalpy in the products.

Activity 71: Modeling Exothermic and Endothermic Reactions

Students create and interpret models of exothermic and endothermic reactions. They can check their list from the previous activity against characteristics of exothermic and endothermic reactions. Energy diagrams for both types of reactions are provided, and students should also be able to draw and correctly label an energy diagram given a specific scenario or thermochemical equation.

Scaffolding: draw an exothermic or endothermic diagram and provide a list of labels. Students can match the terms to the correct position or arrow on the diagram.

Activity 72: Thermochemical Calculations: Mole Ratios

The key focus is on performing calculations involving enthalpy changes, mole ratios, and mass. Key points to emphasize are 1) the relationship between mole ratios and 2) enthalpy changes and the conversions between mass, moles, and energy. Review the use of stoichiometry in thermochemical calculations from activities 60 and 61. Remind students that enthalpy per mole of substance is an important step, and that this may be different for each substance depending on how many moles of each there are in a balanced equation. Also highlight the symbols used for reaction (r) and standard conditions, and how $\Delta_r H^\circ$ is used in a specific way for a balanced reaction. Students should embed the correct way to write these symbols at the beginning.

Scaffolding: have students utilize the step-by-step "how to guide" to work through a number of questions until they can work independently.

Extension: provide practice problems with increasing difficulty levels. Alternatively, teachers could deliver the questions in a quiz situation where students compete to be the first to calculate a problem correctly. Questions (and answers) could be projected onto the board as a series of presentation slides.

Activity 73: Thermochemical Calculations and Mass

Mass is now added as an extra step. Review the conversion between mass and moles using the fact family triangle. Remind students that to calculate any value of one substance (the unknown) in a balanced equation using information from another (the known) then the number of moles must always be used to 'bridge across' between them.

Scaffolding: for the second section, comparing two reactions, students could calculate the enthalpy from each reaction as separate questions. Once the values are confirmed as correct, they progress to comparing the two reactions.

Extension: students can research any of the given contexts for thermochemistry calculations. Thermite reactions are also covered further in redox. Questions 6, 7, and 8 can be set as extension.

Activity 74: Enthalpy of Combustion

This activity introduces the concept of enthalpy of combustion and its calculations. Discuss the precise definition of enthalpy of combustion and link the word definition to the symbol used. Explain the importance of a balanced equation with just one mole of fuel combusted in the equation and why it may result in fractions used for the other reactants or products. Discuss the importance of rules in chemistry. Highlight that even though there are exceptions, such as adding in fractions to an equation, the rules are still useful for the majority of cases.

Students will use combustion equations in Hess's law and in organic chemistry, so it is important that they can expand a balanced equation when just given the formula for the fuel. Link the energy released from organic molecules during combustion to the bond strength between C and H in the covalent bonds.

Activity 75: Enthalpy of Formation

This activity focuses on standard enthalpies of formation and their use in calculations. Emphasize the definition of standard enthalpy of formation and the importance of one mole of product formed. Remind students that the state of the product is at room temperature and they can use the periodic table in activity 19 as a reference. Tables of standard enthalpies of formation for calculations can be developed from information in the worktext and from [reliable data sources](#) online (you may wish to provide some websites).

Extension: discuss the significance of formation enthalpies in predicting reaction feasibility and in calculating the enthalpy of reaction. Questions 5b and 9 can be set as extension.

Activity 76: Enthalpy and Phase Change

This activity explores the relationship between enthalpy and phase changes. It builds on the states of matter content in activity 5, but adds thermochemical data. Latent heat is revisited in more depth. Key points to cover are enthalpy changes during melting, vaporization, and sublimation and energy diagrams for phase changes. Discuss the relative amount of enthalpy required for breaking bonds between solids and liquids, and again between liquids and gases. Use the data from the graph on page 164 to support this. The last question bridges to the concept of specific heat capacity and can be used as an introduction discussion point to activity 77.

Extension: questions 2 and 3b can be set as extension.

Activity 77: Specific Heat Capacity

This activity introduces the concept of specific heat capacity and its calculations. Key points to emphasize in the introductory discussion include the definition of specific heat capacity, and the relationship between heat, mass, specific heat capacity, and temperature change. Students begin with calculations of q , which needs to be clearly understood before calculating the heat of reaction. Ensure students understand why the inverse of q must be used, as heat released and measured by temperature then becomes enthalpy lost in products. The differences between thermochemical data recorded under strict conditions and the actual data collected in a typical school laboratory is used by students in activity 78 as part of their lab report. Explain that the specific heat capacity given is just for water, and that different substances will have different values depending on their structure and bonding.

Scaffolding: when working through the questions, pause and check each part of the calculation has been correctly calculated before moving onto the next step.

Extension: some students may wish to investigate the applications of chemistry example further by exploring the relationship between the specific heat capacity of water and the role of the oceans in climate change. Question 3, page 165 can be assigned as extension material.

Activity 78: Calorimetry Investigation

This activity involves a practical investigation using calorimetry.

Review safety procedures before beginning the experiment. Highlight any key steps and discuss sources of error and how to minimize them. Encourage students to compare their results with literature values.

Extension: question 6 can be set as extension.

Activity 79: Bond Enthalpy

This activity focuses on bond enthalpies and their use in calculating reaction enthalpies. Students will need to draw Lewis structures; refer back to activity 30 if necessary. Students can draw the structures on a blank piece of paper and cross off the bonds as they account for them. Remind students that it is important that they check whether a bond is single, double, or triple as this affects the bond enthalpy. The bond enthalpy tables provided are important tools and act as a type of accounting for students. Reassure students the mathematics is simple, but it is easy to miss a bond if they do not check their work carefully.

Extension: the second type of calculation for determining the

enthalpy of an unknown bond could be used as extension. Question 1c on page 170 can be set as extension material.

Activity 80: Hess's Law

This activity introduces Hess's Law and its application in enthalpy calculations. The manipulation of different equations may seem confusing for students but the cancelling of the same substances on both sides of the equations will allow a check where the final remaining substances must match the initial equation.

Prior knowledge: students can unpack and write balanced equations for enthalpy of combustion and enthalpy of formation.

Scaffolding: use simple analogies like building a house in different stages to illustrate the concept of Hess's Law. For example, explain how the total energy used to build a house is the same whether you build it all at once or in several stages. Questions 1-3 are gradually built up in difficulty. Teachers may wish to partly solve steps for question 4 and 5 as a group to build confidence.

Extension: students could research real-world applications of Hess's Law in industrial processes or environmental science and present their findings as a presentation or poster. Content is identified on pages 174 and 175 as extension. Inviting scientists in to discuss their role would be a nice addition. Schools close to a University or research facility, may be able to undertake a field trip. Students are encouraged to conduct a literature search using as many different types of media as possible.

Chapter 6: Reaction Rate and Equilibrium

The key focus of this chapter is to investigate reaction rates and chemical equilibrium by understanding how factors such as collision frequency, activation energy, temperature, concentration, and surface area influence the speed of chemical reactions. Students examine the principles of collision theory, dynamic equilibrium, and Le Chatelier's principle, and explore how these concepts are applied to optimize industrial processes such as the Haber and Contact processes. Several useful analogies for explaining concepts in this chapter are provided.

Activity 82: Collision Theory

The key focus is for students to understand the basics of collision theory and how it explains chemical reactions at the particle level.

Prior knowledge: students should have a basic understanding of atoms, molecules, and the concept of chemical reactions.

Scaffolding: use physical models or online simulations to visualize particle collisions. Consider using the [Resource Hub](#) for interactive collision theory simulations. Use a ball pit analogy to visualize molecular collisions or demonstrate with ping pong balls or marbles. **Particles in motion:** just like balls in a ball pit, particles in a chemical reaction are constantly moving. The movement of these particles is random, similar to how balls bounce around in the pit. **Collisions:** for a chemical reaction to occur, particles must collide with each other. In the ball pit, balls frequently bump into each other, representing the collisions between reactant particles. **Effective collisions:** not all collisions result in a reaction. For a collision to be effective (resulting in a chemical reaction), it must have sufficient energy and the correct orientation. In the ball pit, this is akin to balls hitting each other with enough force and in the right way to cause a noticeable change.

Extension: research other instances of postulates in science, and how they contribute to science knowledge. Students could discuss collision theory in car safety design. Question 5b can be set as extension.

Activity 83: Activation Energy

This content builds on the previous chapter. This activity has a deeper focus on the concept of activation energy and its role in chemical reactions. Teachers can discuss and compare activation energies of various everyday chemical reactions or introduce the lesson by discussing activation energy in the context of fire safety.

Prior knowledge: review energy diagrams and exothermic/

endothermic reactions. Students understand the concept of energy barriers in reactions.

Scaffolding: use this hill analogy to explain activation energy:

“Imagine a chemical reaction as a journey over a hill. The reactants start at the base of the hill, and to transform into products, they must climb to the top of the hill, which represents the activation energy barrier. Once they reach the top, they can roll down the other side to become products. The height of the hill corresponds to the amount of activation energy required for the reaction to proceed. If the reactants do not have enough energy to reach the top of the hill, the reaction will not occur.”

Extension: challenge students to research and present on real-world applications of activation energy, such as the use of catalysts in industrial processes (links to activity 85). Students could research activation energy in biochemical reactions or explore its importance in food preservation techniques.

Activity 84: Reaction Rates and Influencing Factors

This activity explores factors that influence reaction rates, including concentration, temperature, and surface area. The lesson could begin with a discussion on reaction rates in cooking and food science, something most students will have some familiarity with. Note that temperature affects two different processes, firstly the kinetic energy and secondly the amount of energy present in a collision, and both influence reaction rate. Students must understand that some factors do not change the proportion of effective or successful collisions (leading to a reaction), just the number of collisions, whereas temperature does.

Scaffolding: conduct simple demonstrations to show the effects of various factors on reaction rates. For example, compare the reaction rate (dissolving) of a whole antacid tablet versus a crushed one in water to reinforce the text. Use analogies like “race cars on a track” for reaction rate: the race cars on a track analogy for reaction rates helps to visualize how different factors affect the speed of chemical reactions. Imagine reactant particles as race cars on a track. The speed at which these cars (reactants) complete laps (convert into products) can be influenced by several factors: **Temperature:** increasing the temperature is like giving the race cars more powerful engines, allowing them to move faster and collide more frequently, thus increasing the reaction rate. **Concentration:** increasing the concentration of reactants is like adding more race cars to the track. With more cars on the track, the likelihood of collisions increases, speeding up the reaction. **Surface area:** increasing the surface area of reactants is like widening the track, giving the cars more space to move and collide. This increases the frequency of collisions and the reaction rate. **Catalysts:** adding a catalyst is like providing shortcuts on the track, allowing the cars to complete laps more quickly without needing as much energy. This lowers the activation energy and speeds up the reaction.

Extension: a detailed investigation to test reaction rate using the sodium thiosulfate clock reaction is provided but some students could design and conduct their own experiments to test the effects of different factors on reaction rates. Question 11 can be set as extension.

Activity 85: Catalysts

This activity introduces the concept of catalysts and their role in chemical reactions. The lesson could be started with a discussion on the use and function of catalytic converters in cars or exploring the role of catalysts in sustainable chemistry. Ensure students know that catalysts are not used up (consumed) in a chemical reaction.

Prior knowledge: review activation energy and reaction pathways. Understand the concept of chemical intermediates as introduced in Hess's law previously (activity 80).

Scaffolding: use the interactives or video on the [Resource Hub](#) to demonstrate how catalysts work at the molecular level. Use the “tunnel through a mountain” analogy for catalysts: Without a catalyst, reactants must climb over the mountain, requiring high activation energy. With a catalyst, reactants can pass through a tunnel, requiring much less energy, thus speeding up the reaction.

This analogy illustrate how catalysts provide a lower energy pathway for reactions, increasing the reaction rate.

Extension: assign research projects on the use of catalysts in various industries or in biological systems (enzymes). Students could research and present on different types of catalysts (homogeneous, heterogeneous, biological).

Literacy: students could practice reading scientific articles about catalysts and summarizing the main points or analyze scientific literature on emerging catalyst technologies.

Activity 86: Chemical Equilibrium

The concept of chemical equilibrium and dynamic equilibrium are introduced. Some students may have the misconception that equilibrium is when the amount of reactants and products is equal or that equilibrium is achieved in all conditions. Emphasize the importance of closed systems, dynamic and continuous reactions, and variations in the amounts of reactants to products. Relate the process of collision theory and concentration to the ‘balancing’ of the equilibrium.

Prior knowledge: understand the concept of steady state.

Scaffolding: use physical models such as colored beads or marbles to represent reactants and products.

Use the seesaw analogy to demonstrate chemical equilibrium.

Balanced seesaw: when the seesaw is perfectly balanced, it represents a state of dynamic equilibrium. The rates of the forward reaction (reactants converting to products) and the reverse reaction (products converting back to reactants) are equal, and the concentrations of reactants and products remain constant. **Adding reactants:** if you add more weight (reactants) to one side of the seesaw, it tips in favor of the forward reaction, producing more products until a new equilibrium is established. **Adding products:** if you add more weight (products) to the other side, the seesaw tips in favor of the reverse reaction, converting products back into reactants until equilibrium is restored. **Removing reactants or products:** removing weight from either side will also disturb the balance. The system will adjust by shifting the equilibrium to counteract the change, either producing more reactants or products to re-establish balance.

Extension: question 4 can be set as extension.

Activity 87: The Equilibrium Constant

This activity focuses on the equilibrium constant and how to calculate it. Remind students that solids and liquids are not placed in equilibrium expressions as the concentration cannot change. Students may also think it seems counter-intuitive that products are the numerator and need this explained.

Scaffolding: start with simple equilibrium problems and gradually increase in complexity. Use the step-by-step guide provided on page 194 to help students confidently calculate K_c .

Extension: question 6 can be set as extension.

Literacy: practice writing and interpreting equilibrium expressions. Emphasize the correct use of square brackets for concentration. Remind students that even when a calculation is required for a question, a rational explanation may also be needed to interpret or explain the answer.

Activity 88: Le Chatelier's Principle

These activities explore Le Chatelier's Principle and its applications, including predicting equilibrium shifts. Students may think the same factors for reaction rates apply in equilibrium questions, so emphasize that catalysts do not affect equilibrium, and pressure is now added as an additional factor. Increasing surface area can be considered as increasing concentration of reactants. Questions need to be considered and answered at particle (sub-microscopic) level but also include supporting observations at macroscopic level. Use equations symbolically.

Scaffolding: use analogies to explain Le Chatelier's Principle. For example, the “crowded elevator” analogy can help explain pressure changes. **Increasing pressure:** when the elevator becomes more crowded (pressure increases), people (gas molecules) will try to move to a less crowded space to relieve the

pressure. In a chemical reaction, increasing pressure favors the side of the equilibrium with fewer gas molecules, as this reduces the overall pressure in the system. **Decreasing pressure:** if the elevator becomes less crowded (pressure decreases), people (gas molecules) will spread out to occupy more space. In a chemical reaction, decreasing pressure favors the side of the equilibrium with more gas molecules, as this increases the overall pressure in the system.

Extension: question 5 and the material at the bottom of page 198 can be set as extension.

Literacy: practice writing explanations of equilibrium shifts using correct scientific terminology. Be consistent with terms, including forwards and reverse.

Activity 89: Le Chatelier's Principle and Temperature Change

The influence of temperature requires reviewing endothermic and exothermic reactions. Relate the differences in relative amounts in activation depending on whether the reaction is increasing in the forward or reverse direction. Emphasize that this is the reason a temperature change can also permanently change the equilibrium position (K_c), whereas changing concentration and pressure is only temporary and the K_c will be retained. The "how to guide" in this activity can be used to help students work through the to the last two activities in this chapter. Teachers may want to spend more time with practicing long form answers and observations before moving on. Activity 165 (observations and inferences) could be combined with this activity to build this skill.

Activities 90-91: Investigating and Predicting Change in Equilibrium Systems

These activities provide more practice in observing reactions and then linking them to an explanation at particle level. Discuss the results of the investigations before asking students to write their explanations. Students can refer back to the "how to guide" in activity 89 to help answer the questions.

Activity 92: Industrial Equilibria

This activity focuses on the application of equilibrium concepts in industrial processes. Videos in the **Resource Hub** can be used as initial engagement for the lesson. The Haber process and contact process are referred to in several activities in different chapters; refer back to them if necessary. A key understanding is that increasing factors (e.g. temperature) may increase the reaction rate but equilibrium principles may favor the reverse reaction and limit products. Maximizing yield, therefore, may be a compromise. Students should also realize that many industrial processes involve multiple steps, and multiple factors can be manipulated.

Prior knowledge: students should have a solid understanding of Le Chatelier's Principle (activities 88 & 89) and factors affecting equilibrium (activity 86).

Extension: student groups design their own theoretical industrial process, explaining how they would optimize conditions for maximum yield.

Chapter 7: Substances in Solutions

This chapter explores the properties and behaviors of substances in solutions, emphasizing the concepts of solubility, concentration, and colligative properties. Students will explore the principles of how solutes dissolve in solvents, the impact of temperature and pressure on solubility, and the classification of solutions based on their physical state and particle size. In the second part of the chapter, acidic and basic solutions are explored. This section covers the definitions and interactions of acids and bases, including the Arrhenius and Brønsted-Lowry theories, and calculation of pH and ion concentrations. Through practical investigations, such as titration and the creation of standard solutions, students will gain a comprehensive understanding of how these factors influence chemical reactions and the properties of solutions.

Activity 94: Water as a Solvent

Students learn why water makes an excellent solvent. A common misconception is that students think all substances dissolve in water. Clarify that while water is a "universal solvent," it does not dissolve everything. Some students may believe that dissolved substances disappear. Emphasize that dissolution is a physical change, not a chemical one.

Prior knowledge: students should have a basic understanding of molecular structure and polarity. Review activity 9 if needed.

Scaffolding: use visual aids or molecular models to demonstrate water's polar structure. Activity 41 provides background material, if needed, and the simulation on the **Resource Hub** provides visual engagement. Analogies can be helpful, compare water molecules to tiny magnets, with positive and negative ends attracting different substances.

Extension: research how water's solvent properties are crucial in biological systems or environmental processes.

Literacy: students could read and summarize articles describing water treatment or purification. How are water's solvent properties utilized in these processes?

Activity 95: Types of Solutions

This activity introduces students to different types of solutions, including true solutions, colloids, and suspensions. Students often confuse solutions with pure substances, so clarify that solutions are mixtures. Many students think all solutions are liquids, so provide examples of solid and gaseous solutions to address this misconception.

Prior knowledge: students should understand the concept of mixtures and be familiar with the terms solute and solvent.

Scaffolding: use everyday examples to illustrate different types of solutions. For instance, salt water (true solution), milk (colloid), and muddy water (suspension). Demonstrate the Tyndall effect using a laser pointer to differentiate between types of solutions.

Extension: students could research and present on how colloids are used in different applications (e.g. foods or cosmetics). Question 6 could be extended out to an essay assessment.

Activity 96: Saturated Solutions

This activity focuses on the concept of saturation solutions and the crystallization process. Use the Dead Sea videos on the **Resource Hub** as an engaging introduction. Be aware that students often think a saturated solution cannot be clear. Ask students to pay close attention to what they see during investigation 7.1 to counter this misconception.

Prior knowledge: students should understand solubility and factors affecting it.

Scaffolding: use a simple analogy, like filling a parking lot to capacity, to explain saturation.

Extension: explore how understanding saturation and crystallization is applied in fields such as geology (formation of minerals) or chemical engineering.

Literacy: students could research and write a brief report on the technological applications of crystal growth, such as the production of silicon wafers for electronic devices.

Activity 97: Solubility

Key concepts include defining solubility and the factors affecting solubility: temperature, pressure, nature of solute and solvent. Students may think that all solutes have the same solubility, especially if they are polar or ionic. Compare the solubility of different substances to address this misconception. Other common misconceptions students may have are that all substances dissolve more in hot water and that stirring increases solubility (it only speeds up the process).

Extension: use real-world applications to investigate the solubility of gases in liquids (e.g. carbonated beverages or deep-sea diving). Question 6 can be set as extension.

Activity 98: Factors Affecting Solubility

Up until this activity, the focus has been on liquid or aqueous solutions. Remind students that gases can form mixtures as well. Compare and contrast the factors affecting the solubility of both liquid and gas solutions. Before beginning the investigation, ask students to work in their lab groups and predict the results of the temperature and salt solubility practical. You may wish to discuss how predictions and hypotheses form part of the science process. Note: Students will cover the properties and laws of gases more thoroughly in the next chapter.

Extension: fertilizer solubility has been highlighted as an application of chemistry, students may wish to research this example further.

Activity 99: Solubility Curves

Key skills include reading and interpreting solubility curves and then determining saturation points. Students often misinterpret solubility curves as linear. Use various examples to show non-linear relationships. Many confuse saturation point with the highest point on the curve. Explain that saturation occurs at any point on the curve.

Scaffolding: ensure students can define and distinguish between unsaturated, saturated, and supersaturated. Link the increase in solubility of solids into liquids due to temperature rise (activity 98) with the solubility curve.

Extension: the activity includes a solubility curve for just one salt. Students may wish to research several different 'curves' and compare them.

Activity 100: Molarity, Concentration, and Dilution

Key skills in this activity consist of carrying out a range of calculations including defining and calculating molarity ($M = \text{moles of solute} / \text{liters of solution}$), percent concentration calculations, and dilution calculations ($M_1V_1 = M_2V_2$). The order taught for these calculations is unimportant, but students need to be able to interpret a question and determine which calculation or formula is suitable to solve the problem. Mix up some questions and ask the students to select the correct steps to use. Be aware that students can confuse molarity (the number of moles of solute per liter of solution) with molality (the number of moles of solute per kilogram of solvent) and think that concentration remains constant when adding more solvent. Some students think dilution always results in half the original concentration. Show calculations for various dilution ratios. Ensure that students are familiar with using the correct symbols and units. For example, volume is a capital V in most formulae, but written as lower case v in various percentage volume calculations. Remind them that numbers are rarely used in chemistry without an appropriate unit.

Activity 101: Colligative Properties of Solutions

Discuss applications of colligative properties in everyday life (e.g. antifreeze in car radiators, road salt for de-icing) as an introduction. The three properties involved in phase change are the focus: vapor pressure lowering, boiling point elevation, and freezing point depression. Students often believe colligative properties depend on the nature of the solute. Emphasize that they depend on the number of particles. Students can confuse boiling point elevation with an increase in temperature needed to boil. Clarify the difference between these two points.

Scaffolding: relate the phenomenon to as many real-world examples as possible that students may be familiar with.

Extension: osmotic pressure is a secondary focus, if time is limited this content can be set as homework or extension. Question 5 can be set as extension.

Activity 102: Defining Acids and Bases

Make a clear distinction between Arrhenius and Brønsted-Lowry acid and base definitions, as students may not be familiar with both. If there is time, the contribution of the scientists involved may be expanded upon.

Students may think all acids are strong and all bases are weak. Provide examples of weak acids and strong bases. Some believe pH is the only way to identify acids and bases. Introduce other

methods like indicators and electrical conductivity. Balancing of equations may need to be revisited.

Scaffolding: provided a list of acids and bases and students then sort them into categories. Students can develop a comparison chart or Venn diagram to compare and contrast the properties of Arrhenius and Brønsted-Lowry acid and bases, writing examples in each area, i.e. those that are both types, those that are only one type.

Extension: questions 2 and 5 can be set as extension.

Activity 103: Strong and Weak Acids and Bases

Be clear on the characteristics of strong vs. weak acids and bases and link to degree of dissociation. Emphasize that the degree of strength is on a continuum, and therefore classification of weak or strong is not clear cut; some solutions fall between. Students often think strong means concentrated and weak means dilute. Clarify the difference between strength and concentration. Many believe all strong acids/bases have the same strength. Compare the pH of different acids/bases on the scale.

Extension: question 4 can be set as extension.

Activity 104: Acid and Base Reactions in Water

Discuss the formation of hydronium ions and why they are more likely to form than just hydrogen ions in an aqueous solution. Link back to the polar structure of water. It may help to draw the reactants at a particle level, to show the non-bonding pairs and why some substances donate while others accept hydrogen ions. Students may think all acid-base reactions produce neutral solutions. Showing titration curves of strong and weak acid/bases may be useful.

Extension: question 3 can be set as extension.

Activity 105: Conjugate Acids and Bases

Students often struggle to identify conjugate pairs. Practice identifying these in various reactions. Not all strong acids always have weak conjugate bases; show exceptions such as HSO_4^- . Discuss the use of double or single arrows in the equations and link back to equilibrium principles in the previous chapter. Also discuss what species are likely to be found in each type of solution at the beginning and end of each type of reaction.

Scaffolding: provide partially completed equations or complete them with students on the board before students independently complete them. Provide feedback through the process so students become confident in balancing these equations.

Extension: question 4 can be set as extension.

Activity 106: pH and Ions

Students are likely to come into the course with prior knowledge on acids, bases, and pH. However, many may not understand that the pH is not an arbitrary classification, but instead a real-world, albeit at sub-microscopic level, phenomenon. Explain that the acids and bases need to be in an aqueous solution in order to dissociate into ions (by reacting with water) that then result in a specific pH. Key concepts are 1) the pH scale and 2) calculations and the relationship between $[\text{H}^+]$ and $[\text{OH}^-]$. Students frequently believe pH only applies to acids. Clarify that pH scale covers both acids and bases. Some think pH directly measures H^+ concentration. Explain the logarithmic nature of pH. Teachers can provide a strong and weak acid or base listed in the previous activity, and ask students to work through the "how to guide" on linking pH to ion concentration and conductivity on page 237 to compare the two.

Extension: investigate the use of pH in environmental monitoring (e.g. water quality testing) or an industrial process such as cheese making. The blue panel on page 236 can be set as extension or set to all students with teacher guidance.

Activity 107: Indicators

Students use different indicators to test pH and compare the advantages and disadvantages each. If time allows, students can make a red cabbage indicator (investigation 7.4). Remind students that the color scales for each indicator are different.

Scaffolding: a large pH scale can be drawn, students can estimate

pH of various solutions then add in the actual value after they complete their investigations.

Extension: questions 8 and 11 can be set as group work or extension.

Activity 108: pH Calculations - Strong Acids and Bases

At this level, only strong acid and base calculations are required. The first part of the activity unpacks the formula used, using equilibrium principles. Discuss with students how they must have an expectation of a sensible answer for pH and critically evaluate the value they calculate; does it make sense? Values outside of 0-14 are incorrect. Students should be able to recall the pH range of strong acids, weak bases and benchmark their answers against this. The answers for ion concentration typically use scientific notation. Teachers may wish to use activity 168 to distinguish between scientific notation and standard notation. Additionally, teachers may request a specific level of precision for their answers. Scientific notation often uses 3 significant figures for answers (activity 166) but if using standard notation for pH values, teachers may wish for a consistent 1 decimal place. A guide to using a scientific calculator to calculate pH is provided on page 244. Ensure that students can locate and use the functions on their calculator.

Extension: questions 9 and 12 can be set as extension.

Activity 109: Acid-Base Neutralization

Students often think neutralization always results in pH 7. Demonstrate or discuss salt hydrolysis leading to non-neutral pH. Make sure that students are given neutralization examples with polyprotic acid or base reactions to show that the ratio is always not always 1:1. Teachers may want to spend more time on different reactions and compare between carbonates and hydrogen carbonates. Students may have a misconception that all neutralization reactions produce a salt and water, but need to be reminded that carbon dioxide can also be a product depending on the base. This can be reinforced by a classroom demonstration of mixing sodium bicarbonate and vinegar where students observe the gas (confirmed as cloudy limewater).

Activity 110: Standard Solutions

Students may think volume doesn't change when dissolving solutes, so emphasize the importance of adding the solid to a small amount of water first and then slowly adding water to make up the final volume. Before attempting investigation 7.7, students can practice correctly filling the flask with colored water (add dye) so the level sits on the bottom of the meniscus on the line. Discuss the importance of avoiding parallax error and look at the line level straight on.

Activity 111: Titration

A teacher-led demonstration of titration is recommended, followed by students practicing the technique to develop proficiency. Remind students to avoid parallax error (above) when viewing the meniscus for readings. A white tile or a piece of white card to hold behind the glassware can make reading the scale easier. Burette readings may be at 2 d.p., smaller intervals than the volume markings, so students may need to estimate values if they fall between the graduation marks. Remind students they do not have to fill the burette up to exactly the top each time, but they must take an accurate reading of the start point each time. Remind students to add indicator to the flask before starting the titration. There is a skill in holding the flask and swirling and releasing and controlling the stopcock at the same time. Students can work in pairs if coordination of the skills is too difficult. A quick trial titration is recommended in the first instance; it will likely over-run the stop point, but will give students an estimation of when to slow down the flow, often to a drop at a time, for the actual trials. The indicator should hold for over 10 seconds. When students recognize they are close to endpoint, they should stop the burette flow and swirl the flask, holding it against the white tile or card. The color can disappear after around 15 seconds and still be a valid endpoint. Printed color photos showing the indicator color for endpoint and overshoot are helpful.

Chapter 8: Gases and Gas Laws

The key focus of this chapter is to explore the properties and behaviors of gases, emphasizing the concepts of compressibility, expansion, and diffusion. This expands on the initial concepts of matter properties covered in chapter 1. Students will delve into the principles and application of the kinetic molecular theory and various gas laws, including Boyle's Law, Charles's Law, and Gay-Lussac's Law. Through practical activities and theoretical questioning, students will gain a comprehensive understanding of how temperature, pressure, and volume interact in gas systems, and how these interactions are predicted by the ideal gas law. This chapter aims to equip students with the knowledge to apply these concepts in real-world scenarios, such as weather balloons, refrigeration systems, and space exploration.

Activity 113: Properties of Gases

In this activity, the key focus is for students to understand the unique properties of gases and how they differ from solids and liquids. Students may think gases have no mass. Dispel this by weighing a balloon before and after inflation. Some students may believe gases always spread out to fill containers instantly. Explain that diffusion takes time, especially for larger volumes.

Prior knowledge: students should already have a basic understanding of states of matter (activity 5) and collision theory (activity 82).

Scaffolding: use visual aids like balloons or syringes to demonstrate gas compressibility and expansion to support the models drawn on page 256. Consider using the interactive gas behavior simulations on the **Resource Hub** for engagement and visualization. Model gas particle behavior by having students constantly moving around the room in random directions. The students represent gas particles. Just like gas particles, the students move freely and collide with each other and the walls of the room. Add more students so the room becomes more crowded (similar to increasing the pressure); the students have less space to move and bump into each other more frequently. Expand the space students can move into (similar to increasing the volume); the students have more space to move around and the collisions become less frequent. If the students start moving faster (similar to increasing the temperature), they will collide with each other and the walls more forcefully, increasing the overall pressure in the room.

Extension: research or discuss more real-world applications of gas properties, such as in air bags or pneumatic tools.

Literacy: read and summarize scientific articles on gas behavior in extreme conditions, such as deep sea or outer space environments.

Activity 114: Kinetic Molecular Theory

In this activity, the key focus is for students to understand the kinetic molecular theory and how it explains gas behavior at the particle (sub-atomic) level. Students may think gas particles are stationary, so emphasize their constant, random motion. Some students may believe all gas particles move at the same speed; explain the distribution of particle speeds.

Prior knowledge: students should already have a basic understanding of gas properties and particle motion.

Scaffolding: Use physical models or online simulations to visualize gas particle motion, consider using the interactive simulations on the **Resource Hub**. Use analogies like bumper cars to illustrate particle collisions and motion. Imagine a bumper car arena where each car represents a gas particle. The bumper cars move around in random directions, constantly colliding with each other and the walls of the arena. These collisions are similar to the elastic collisions of gas particles, where no kinetic energy is lost. When the bumper cars collide, they bounce off each other and the walls, changing direction but maintaining their speed. If the speed of the bumper cars increases (analogous to increasing the temperature), the collisions become more frequent and forceful, similar to how

gas particles behave at higher temperatures.

Extension: question 4 can be set as extension

Activity 115: Particle Motion and Kinetic Energy

In this activity, the key focus is for students to understand the relationship between particle motion and kinetic energy in gases. Students may think all particles in a gas have the same kinetic energy, so explain the distribution of energies. Students may believe kinetic energy only relates to speed, not mass. Emphasize both factors in the kinetic energy equation. Students could use a Venn diagram to compare and contrast elastic and inelastic collisions to solidify understanding.

Prior knowledge: students should already have a basic understanding of kinetic energy and temperature.

Scaffolding: use physical demonstrations like shaking a jar of marbles to illustrate increased particle motion with energy input.

Extension: investigate how particle motion relates to other forms of energy, such as sound or heat transfer. Question 2 can be set as extension.

Activity 116: Temperature and Kinetic Energy

Students should gain an understanding of the relationship between temperature and kinetic energy in gases. Students may think temperature directly measures kinetic energy. Explain it's an average of particle energies. Some believe 0°C means no particle motion. Clarify the difference between Celsius and Kelvin scales.

Prior knowledge: students should already have a basic understanding of temperature scales and kinetic energy.

Extension: investigate the concept of absolute zero and its implications for particle motion. Question 2 can be set as extension.

Activity 117: Pressure in Gas Systems

The key focus is for students to understand gas pressure, its measurement, and factors affecting it. Students may think pressure only acts downward. Demonstrate or discuss that pressure acts in all directions. Some students may confuse pressure and force as the same thing, therefore clarify the relationship between pressure, force, and area. A number of different concepts are covered in this activity, including Dalton's law, Torricelli's experiments, and converting between different pressure units. Place a checklist of tasks on the board so students can keep track of them. and then application in gas transportation and refrigeration. The application of chemistry examples can be used to contextualise the principles.

Scaffolding: use physical demonstrations like pushing on a balloon to induce deformity to illustrate pressure.

Extension: investigate real-world applications of gas pressure, such as in weather systems or hydraulic machines.

Literacy: read and summarize scientific articles on high-pressure phenomena in nature and technology.

Activity 118: The Gas Laws

Students should understand the gas laws and how they relate pressure, volume, and temperature by the end of this activity. Students may think gas laws always apply to real gases. Explain limitations and ideal gas assumptions. Students may think that each gas law operates in isolation, so emphasize how they interrelate in real situations. It may be easier to consider all of the three gas laws listed on page 266 as one relationship. Students need to practice the skill of selecting the correct law and equation for the question. Make sure the students are confident with the individual gas laws before moving onto the combined law.

Remind students to write down their working so their process can be followed more easily, and corrected if required. You could use Investigation 8.1 to introduce the activity for an alternative delivery sequence.

Activities 119 & 120: Ideal Gas Law and Using the Ideal Gas Law

These activities could be delivered together. The key focus is

for students to understand the ideal gas law and then apply it to solve problems and understand its practical applications. Remind students that this formula is used wherever mass and moles are mentioned in the question. Spend some time emphasizing the standard pressure and temperature conditions so that students can place the values into the formula when required. Students may forget to convert temperatures to Kelvin, so emphasize the importance of using the correct units.

Some may struggle with rearranging the equation. Practice isolating different variables in the ideal gas law.

Prior knowledge: students should already have a basic understanding of the individual gas laws (activity 118).

Extension: investigate how the ideal gas law is used in the design of pressure vessels or gas storage systems.

Literacy: read and summarize scientific articles on applications of the ideal gas law in various fields, such as meteorology or engineering.

Chapter 9: Redox Reactions and Electrochemistry

The key focus of this chapter is to explore the principles and applications of redox reactions and electrochemistry. Students will cover the concepts of oxidation and reduction, understanding the transfer of electrons between substances. They will learn to balance redox equations, identify oxidizing and reducing agents, and use oxidation numbers to track electron transfer. Additionally, the chapter covers the activity series of metals, the workings of voltaic and electrolytic cells, and the practical applications of electrochemistry in refining metals and preventing corrosion. Through hands-on investigations, students will gain a comprehensive understanding of how redox reactions are integral to everyday processes and industrial applications.

Activity 122: Introduction to Redox Reactions

This activity could begin with a brainstorming session to explore the question 'What are redox reactions?'. Students may mistakenly believe that oxidation always involves oxygen, so emphasize that it actually refers to electron transfer. Confusion of oxidation and reduction is common, so use mnemonics like "OIL RIG" (Oxidation Is Loss, Reduction Is Gain) to help understanding. Students may be used to considering reactions at a macroscopic level, through observations, and require more practice to combine this representation with sub-microscopic and symbolic representation.

Activity 123: Reduction and Oxidation

Student focus is on understanding the processes of reduction and oxidation in terms of electron transfer. Students may think the species being reduced is the reducing agent. Clarify the roles of oxidizing and reducing agents. Some may struggle with identifying which species is oxidized or reduced. so encourage the use of oxidation numbers to track changes.

Students need to be able to identify species in an equation, i.e. the reactant and the product formed from it.

Scaffolding: support students to write two half equations from a full equation. Check in at each step before having the students work independently.

Activity 124: Exploring Redox Reactions

In this activity, students will apply their knowledge of redox reactions to understanding the outcomes of practical experiments. Students may expect all redox reactions to be visibly dramatic, so discuss how some redox reactions can be subtle. Practice identifying which ions actually participate in the redox reaction to help students identify spectator ions.

Scaffolding: work through the investigation steps with the class, identifying safety issue and key steps. Ensure all students have a hands-on experience during the investigation and assign roles if necessary.

Literacy: encourage detailed observations and proper scientific

writing in lab reports.

Activity 125: Activity Series

Students will learn about the reactivity series of metals and how to use it to predict redox reactions. Students may think the activity series is absolute, discuss how factors like concentration can affect reactivity. Some may struggle with predicting reactions involving non-metals. Emphasize that the series primarily deals with metals.

Prior knowledge: students should understand basic redox concepts and how to write chemical equations.

Scaffolding: start with comparing just two metals, then gradually introduce more complex comparisons.

Extension: practice writing balanced redox equations based on the activity series.

Activity 126: Using an Activity Series

Students apply their knowledge of the activity series to predict and explain redox reactions. Students may think all metals above hydrogen in the series will react with acids. Clarify the role of oxide layers in some metals.

Scaffolding: start with simple replacement reactions, then progress to more complex scenarios.

Extension: explore how the activity series relates to standard reduction potentials in electrochemistry.

Literacy: set the application of chemistry examples as additional reading for students who have completed the questions. Encourage students to explain their predictions using proper chemical terminology.

Activity 127: Oxidation Numbers

Students learn how to assign and use oxidation numbers in redox reactions. Students may think oxidation numbers always correspond to actual charges, so clarify that they are a useful construct, not always real charges. Explain to students to count common polyatomic ions as a unit with the oxidation number.

Scaffolding: support students by working through the how to guide. Start with simple elements and compounds and progress to more complex molecules.

Extension: go back to previous activities and use oxidation numbers to confirm the identification of reactants.

Activities 128 & 129: Balancing Redox Equations

These activities can be delivered together. Students practice writing and balancing redox half-equations. Emphasize the importance of charge balance as well as balancing atoms. Highlight the importance of cancelling out common terms when combining half-equations. Provide practice in identifying which species actually participate in the redox reaction so students can identify spectator ions easily.

Prior knowledge: students should understand oxidation numbers and basic redox concepts.

Scaffolding: start with simple half-equations and progress to more complex ones involving H^+ and H_2O .

Extension: in activity 128, questions 1c, 2c, are identified as extension. In activity 129, questions 4, 5, 8, and 9 are extension.

Activity 130: Electrochemistry

Consider using this activity as an engagement starter so students can brainstorm what they know about batteries.

The activity introduces students to the basic principles of electrochemistry and its applications. Students may think electrons flow through the salt bridge. Clarify that the salt bridge allows ion movement to maintain charge balance.

Some may confuse the anode and cathode in different types of cells. Emphasize how these change between voltaic and electrolytic cells.

Prior knowledge: students should have a solid understanding of redox reactions and electron transfer.

Literacy: encourage research and presentation on the historical development of electrochemistry.

Activity 131: Voltaic (Galvanic) Cells

In this activity, students will learn about the structure and function of voltaic cells. Students may think the anode is always on the left in cell notation, so clarify its dependence on the relative positions in the activity series. Use mnemonics like "RED CAT" (Reduction at Cathode) to help students remember the direction of electron flow.

Scaffolding: Use diagrams and models to explain the components of a voltaic cell.

Literacy: practice writing cell notation and explaining the meaning of each component.

Activity 132: Applications of Voltaic Cells

Students explore practical applications of voltaic cells, focusing on batteries. Some may think higher voltage always means more power. Discuss the importance of both voltage and current capacity. Students may think all batteries are voltaic cells so clarify the difference between primary and secondary cells. Primary cells are non-rechargeable batteries that are designed for single-use. Once the chemical reactions within these cells are complete, they cannot be recharged and must be disposed of. Examples include alkaline batteries and zinc-carbon batteries. Secondary cells (rechargeable batteries) act as voltaic cells when discharging, but when an external power source is applied, they can be recharged and used multiple times. They are designed to allow the chemical reactions to be reversed by applying an external electrical current, restoring the original reactants. Examples include lithium-ion batteries and lead-acid batteries.

Scaffolding: start with simple batteries (e.g. making a lemon battery), then progress to more complex commercial batteries.

Extension: investigate the environmental impact of different types of batteries and research emerging battery technologies.

Activity 133: Rechargeable Batteries

In this activity, students will learn about the principles and applications of rechargeable batteries. Some may believe that all batteries are rechargeable and that rechargeable batteries last forever. Discuss the factors that affect battery lifespan. Emphasize that, during discharge, the battery acts as a voltaic cell and the flow of electrons is spontaneous and is the result of electron transfer through a circuit due to a redox reaction. On the other hand, charging a battery is an electrolytic reaction, where the input of energy causes the electrons to flow in the opposite direction, and the direction of the reaction is reversed (products once more become reactants).

Prior knowledge: students should understand basic voltaic cell concepts and reversible reactions.

Scaffolding: compare and contrast primary (voltaic) and secondary (electrolytic) cells. Use diagrams to explain the charging and discharging processes.

Extension: investigate the chemistry behind different types of rechargeable batteries (Li-ion, NiMH, lead-acid, etc.).

Literacy: encourage research on the development of rechargeable battery technology and its impact on society.

Activity 134: Electrolytic Cells

This activity can be taught in conjunction with the previous activity so students understand that rechargeable batteries have both voltaic (electrochemical) and electrolytic processes. In this activity, students will compare electrolytic cells and voltaic cells. Students may confuse the anode and cathode in electrolytic cells, so emphasize how these differ from voltaic cells. Some may think electrolysis always produces elements so introducing cases where compounds are produced (e.g. in the chloralkali process) can help with this misconception.

Prior knowledge: students should understand voltaic cells and non-spontaneous reactions.

Scaffolding: compare and contrast voltaic (electrochemical) and electrolytic cells. Use Venn diagrams to explain the components

and processes in electrolytic cells.

Activity 135: Electrolysis

Students build their understanding of electrolysis from the previous activity and explore its applications. Investigation 9.5 allows hands-on exploration of one application, electroplating, for themselves. Students may think the products of electrolysis are always predictable based on the electrolyte. Discuss how electrode material and concentration can affect products.

Scaffolding: start with simple electrolysis reactions (like water electrolysis), then progress to more complex systems.

Extension: investigate quantitative aspects of electrolysis, including Faraday's laws.

Literacy: encourage students to research and present on industrial applications of electrolysis.

Chapter 10: Organic Chemistry

The key focus of this chapter is to explore the properties and behaviors of organic molecules, emphasizing the concepts of structure, reactivity, and functional groups. Students will cover the principles and conventions of organic chemistry, learning about hydrocarbons, alcohols, carboxylic acids, and polymers. They will investigate various types of organic reactions, including substitution, addition, esterification, and polymerization, and understand how these reactions are interconnected. Through practical activities and theoretical knowledge, students will gain a comprehensive understanding of the diverse and complex nature of organic compounds. Naming of functional groups and reactions can be supported throughout this chapter with a range of tutorial videos in the [Resource Hub](#).

Activity 137: Introduction to Organic Compounds

Watch the video on the [Resource Hub](#) as an introduction to the topic. Students may think all compounds containing carbon are organic. Clarify that compounds like CO_2 and carbonates are exceptions. Some may struggle with the concept of isomers. Use physical models to demonstrate structural differences. For more practice, provide students with a molecular formula of an alkane, such as C_6H_{14} , and ask them to draw as many different arrangements (isomers) as possible. At this stage naming is not needed, but students need to know how to draw molecular, structural, and condensed structural forms, and convert between them.

Scaffolding: provide some worked examples before having students complete the rest of the questions in a set.

Extension: investigate the role of organic compounds (e.g. proteins, carbohydrates, and nucleic acids) in living systems.

Literacy: read and summarize articles on the history of organic chemistry and its impact on modern society.

Activity 138: Alkanes

The key takeaway is for students to understand the structure, nomenclature, and properties of alkanes. They will also need to obtain a firm understanding of naming conventions which are modified slightly for each different organic group. Students may confuse the prefixes used in naming (e.g. meth-, eth-, prop-), so provide mnemonic devices to help them remember. Emphasize the importance of careful counting and consider all possible chains when it comes to identifying the longest carbon chain in branched alkanes.

Prior knowledge: students should be familiar with covalent bonding and understand that carbon can form four bonds, oxygen forms two bonds (often in the form of one double bond), whereas hydrogen and halogens form one bond.

Scaffolding: begin with simple, straight-chain alkanes before introducing branched structures. Ensure students use the IUPAC naming system systematically.

Extension: explore the concept of cycloalkanes and compare their unique properties to straight-chain alkanes. Students can delve into more detailed naming using alkanes that have three or four branches. They can practice how to order branches alphabetically, and understand when commas, hyphens, or spaces are used. This can be supported with tutorial videos in the [Resource Hub](#).

Activity 139: Properties of Alkanes

Students will understand and predict the physical and chemical properties of alkanes based on their structure. Students may assume all alkanes are gases at room temperature. Link to commonly used alkanes and alkane mixtures (e.g. BBQ and laboratory gas, gasoline/petrol or diesel in the car). Clarify the relationship between chain length and physical state. Some may think alkanes are highly reactive, so highlight their relative inertness compared to other organic molecules, link this knowledge to chain length. Clarify why alkanes are known as saturated hydrocarbons. Use the tutorial videos in the [Resource Hub](#) to help students name functional groups and reactions.

Scaffolding: start by discussing simple properties like boiling point and solubility, then progress to more complex concepts like reactivity.

Extension: investigate the relationship between alkane structure and properties, for example, octane rating of fuels.

Literacy: interpret and communicate information on melting point and boiling point of alkanes (page 311).

Activity 140: Alkenes and Alkynes

In this activity, the key focus is for students to understand the structure, nomenclature, and properties of alkenes and alkynes, and compare them to alkanes. Distinguish between saturated and unsaturated hydrocarbons. Students may confuse the suffixes -ene and -yne so creating a mnemonic can help them remember which is which. Molymods (molecular models) can be used to show that the double bond cannot rotate. Students should be able to draw the structure of the isomers and explain how that structure relates to the different physical properties. Differentiation between structural isomers and geometric isomers should be understood.

Scaffolding: start with simple alkenes and alkynes before introducing more complex structures. Emphasize the importance of the position of double/triple bonds in naming.

Extension: explore the concept of geometric isomerism in alkenes. Link the isomer to the physical property of boiling point and reasons for the difference between isomers. Question 7 can be set as extension.

Activity 141: Alcohols

Students should understand the structure, nomenclature, and properties of alcohols by the end of this activity. Students may think all compounds with -OH are alcohols. Clarify that the -OH must be bonded to a carbon atom for this to be true. Some may struggle to understand why alcohols have higher boiling points than alkanes, use hydrogen bonding to explain this phenomenon. The oxidation investigation introduces two new organic functional groups, aldehydes (suffix -al to replace -ane on alkanes) and carboxylic acids. Spend some time practicing the naming (with branching for extension students) to ensure students can distinguish between the groups before moving on. Revise the process of oxidation reactions, although students will not have to balance these reactions using redox conventions. You may wish for the students to start drawing an organic scheme on a large piece of paper, and add the groups, naming conventions, and the reactions between them (with reagents). Continue to add to it as you work through the chapter. Compare it to the reaction scheme at the end of the chapter.

Scaffolding: begin with simple primary alcohols before introducing secondary and tertiary alcohols. Emphasize the importance of the -OH group in naming and properties.

Extension: investigate the oxidation of alcohols to aldehydes and carboxylic acids.

Activity 142: Fuels and Combustion

The key focus is for students to understand the use of hydrocarbons as fuels and the process of combustion. Students may think all combustion reactions produce only CO_2 and H_2O . Introduce the concept of incomplete combustion.

Some may struggle with understanding why different fuels have different energy outputs. Relate this to bond energies and molecular structure.

Scaffolding: start with simple combustion reactions of methane before progressing to more complex hydrocarbons. Emphasize the importance of balancing equations.

Extension: investigate the environmental impact of hydrocarbon combustion and explore alternative fuel sources.

Literacy: analyze articles on fuel efficiency and emissions.

Activity 143: Polymers

In this activity, the key focus is for students to understand the concept of polymers and their properties. At this stage the distinction between addition polymerization and condensation polymerization is not made, the emphasis is on properties. Students may think all polymers are plastics, highlight examples of natural polymers like proteins and cellulose to counter this. Compare the natural polymers (e.g. polypeptide chains) to synthetic polymers.

Extension: investigate the properties of different polymers and their applications in everyday life. Students could also investigate the history and impact of a particular polymer, such as nylon or PVC.

Activity 144: Substitution Reactions

The key focus of this activity is for students to understand the concept and mechanism of substitution reactions in organic chemistry. Haloalkanes are introduced. You may wish to spend some time reviewing the prefixes and providing some naming practice before moving on to the substitution investigation (10.2). If a reaction scheme is being built (see notes for activity 141), give students time to add the new functional group and reaction. Students may think all substitution reactions occur in the same way. Emphasize the differences in mechanism depending on the substrates and conditions, including reagents. Discuss the purpose of a reagent for a given organic reaction, and how the condition such as UV light provides the activation energy for a reaction to occur. Some may struggle with understanding why some groups are better leaving groups (hydrogen ions) than others. Relate this to bond strengths and stability of ions.

Activity 145: Addition Reactions

Students should understand the concept and mechanism of addition reactions, particularly in alkenes and alkynes by the end of this activity. Students may think all addition reactions follow the same pattern, so spend time highlighting the differences in products, depending on the reagents used. Explore Markovnikov's rule and its applications in predicting products of addition reactions. Extended time may be needed for students to understand the two different products formed.

Scaffolding: start with simple examples of hydrogenation and halogenation before introducing more complex additions. Use step-by-step diagrams and molecular models to illustrate reaction mechanisms.

Extension: investigate elimination reactions, haloalkanes to alkenes, and the major and minor products using the "reverse Markovnikov's rule".

Literacy: practice writing and balancing equations.

Activity 146: Addition Polymerization

Students should understand the process of addition polymerization and its applications in producing common plastics. For drawing tasks, remind students that the carbons previously forming the double bonds are the 'linking' carbons in the long chain. Any other groups will be 'hanging' off the chain on every second carbon.

Scaffolding: start with simple examples like polyethene before progressing to more complex monomers. Use diagrams to show how monomers link together.

Extension: investigate the properties of different addition polymers, such as polyethene and polypropene, and how they relate to their structure.

Literacy: research and report on the environmental impact of addition polymers and efforts to make them more sustainable.

Activity 147: Condensation Reactions

Students should understand the concept of condensation reactions, particularly in the formation of esters and amides. The use of clear diagrams to illustrate addition and condensation polymerization will help students distinguish between these processes. Students may confuse condensation with dehydration synthesis, so emphasize that condensation specifically produces water as a byproduct. Some may struggle with understanding the reversibility of condensation reactions. You could introduce the concept of hydrolysis as the reverse process to counter this (it is covered in detail in activity 148).

Scaffolding: start with simple ester formation before progressing to more complex condensation reactions. Use step-by-step diagrams to illustrate the mechanism.

Extension: question 7 can be set as extension.

Literacy: practice naming esters and identifying the alcohol and acid components from the ester name.

Activity 148: Hydrolysis

Students should understand the process of hydrolysis and its applications in breaking down organic compounds. Students may think all hydrolysis reactions occur spontaneously in water. Emphasize that heat or the presence of a catalyst is often necessary. Some may struggle with understanding the products of hydrolysis for different compound types. If using, continue to add to the reaction scheme showing typical hydrolysis products for various organic compounds.

Extension: investigate the role of enzymes in biological hydrolysis reactions (e.g. human digestion or production of protein hydrolysates for nutritional supplements). Question 4 can be set as extension.

Activity 149: Saponification

The primary goal of this activity is for students to understand the process of saponification and its application in soap making. Students may confuse saponification with simple hydrolysis, therefore emphasize the role of the strong base in the saponification reaction. Use diagrams to illustrate the amphipathic nature of soap molecules and how this property can be used to clean.

Scaffolding: begin with the basic reaction of a simple ester with a strong base before introducing the hydrolysis of triglycerides in soap making.

Extension: investigate in more depth how soaps work to clean oils and grease. Questions 4 and 5 can be set as extension.

Literacy: research the history of soap making and its cultural significance in different parts of the world.

Activity 150: Functional Groups

This task focuses on the functional groups in organic chemistry and how the groups affect the properties of molecules. Students may confuse similar-looking functional groups (e.g. aldehydes and ketones). Take time to show the subtle differences in structure and position between similar groups.

Some may struggle to understand how functional groups affect physical properties. Use analogies or demonstrations to illustrate concepts like polarity and hydrogen bonding. A large list of functional groups is provided. Teachers may wish for students to highlight the groups they will focus on, and in particular in reactions, and undertake more naming practice for these groups.

Scaffolding: introduce functional groups one at a time, explaining

their structure and general properties. Use consistent color coding or symbols for each group.

Extension: Question 4 can be set as extension.

Activity 151: Organic Reactions Summary

This review activity allows students to revise and synthesize their understanding of named organic reactions. Students may struggle to see the bigger picture of how reactions are interconnected. To aid this, finalize construction of the class flow charts or reaction scheme to visualize relationships. Compare it to the reaction scheme in the worktext. Some may have difficulty applying their knowledge to unfamiliar compounds. Provide practice with novel molecules, encouraging students to apply general principles when solving problems.

Scaffolding: practice categorizing reactions (e.g. addition, substitution, condensation) before exploring how they interconnect.

Extension: predict products of multi-step reaction sequences.

Chapter 11: Nuclear Chemistry

The key focus of this chapter is to explore the principles of nuclear chemistry, emphasizing the concepts of radioactivity, nuclear reactions, and the applications of nuclear energy. Students will revisit the structure of the atomic nucleus, the nature of radioactive decay, and the different types of radiation. They will also learn about the processes of nuclear fission and fusion, the concept of half-life, and the practical uses of nuclear power in electricity generation and medical diagnostics. This chapter aims to provide understanding of how nuclear reactions release energy and the impact of radiation on humans

Activity 153: The Atomic Nucleus

Students will explore the structure and properties of the atomic nucleus. Students may think all nuclei are stable, so explain that some nuclei are unstable and undergo radioactive decay. Some may struggle with the concept of isotopes and confuse them with different atom structures (and hence elements). Explain how atoms can have the same number of protons but different numbers of neutrons.

Prior knowledge: students should understand basic atomic structure.

Scaffolding: start with simple atoms such as hydrogen and helium, then progress to heavier elements.

Activity 154: Radioactive Decay

Students will learn about different types of radioactive decay and their effects. Ensure that students can distinguish between the different types of radioactive decay. Students may think all radiation is harmful so this is an opportunity to discuss natural background radiation and uses of radiation in medicine (page 342).

Prior knowledge: students should understand basic atomic structure and the concept of isotopes.

Extension: explore the concept of transmutation and how elements can change through radioactive decay.

Activity 155: Half-life

This activity includes a hands-on investigation designed to help students explore the concept of half-life. It also explores its applications in dating techniques. Ensure students are familiar with the definition of half life in chemistry as 'the time required for half the atoms in a radioactive sample to decay'. Use visual aids and the hands-on investigation to illustrate the concept of exponential decay.

Prior knowledge: students should understand basic radioactive decay concepts.

Scaffolding: start with simple half-life calculations, then progress to more complex decay curves.

Extension: investigate carbon-14 dating and its applications in

archaeology.

Literacy: encourage students to research and present on other radiometric dating techniques.

Activity 156: Energy Release

In completing this activity, students will learn about the energy released in nuclear reactions and Einstein's famous equation $E = mc^2$. Students may think that mass is actually converted into energy. Clarify that mass and energy are equivalent forms of the same thing. Some may struggle with the enormous scale of energy released. Use comparisons to familiar energy sources to provide context.

Prior knowledge: students should understand basic concepts of energy and mass.

Scaffolding: start with the concept of mass defect, then introduce binding energy, and finally explore Einstein's equation.

Extension: investigate the energy released in specific nuclear reactions.

Literacy: encourage students to research and present on the development (including pros and cons) of nuclear energy.

Activity 157: Nuclear Fission

The central purpose of this activity is to explore nuclear fission reactions and their applications. Students may think all heavy elements undergo fission easily. Discuss the importance of specific isotopes like uranium-235. Use visual aids and the glossary definitions to clearly define between fission and fusion (covered later), as these two processes are often confused.

Prior knowledge: students should understand basic atomic structure and radioactive decay.

Scaffolding: start with simple fission reactions, then introduce chain reactions and critical mass.

Extension: investigate the design of different nuclear reactors and how they control fission reactions.

Activity 158: Nuclear Power

In this activity, students will learn about the principles and applications of nuclear power generation. Outline the principles and include reference to the requirement for large amounts of water for cooling. Highlight uses of nuclear power that students may be unaware of such as desalination processes and hydrogen production (page 349).

Prior knowledge: students should understand basic concepts of nuclear fission and energy conversion.

Extension: investigate the pros and cons of nuclear power compared to other energy sources. Question 3 could be an extension question where students research notable meltdown occurrences (e.g. Chernobyl, Fukushima, or Three Mile Island).

Activity 159: Nuclear Fusion

This activity explores nuclear fusion reactions and their potential as an energy source. It also provides an opportunity to clearly solidify the distinction between fission and fusion. Starting with the statement that fusion created all the elements in the universe is an interesting starting point. Emphasize the huge amounts of energy required for a fusion reaction to occur. If not addressed already, use visual aids and the glossary definitions to clearly define between fission and fusion.

Scaffolding: start with simple fusion reactions like those in the Sun, then introduce the challenges of creating fusion on Earth.

Literacy: encourage students to research and present on the potential use of fusion reactors (page 351).

Activity 160: Radiation and Humans

Although there are many useful applications of radiation (e.g. medical imaging) this activity primarily focuses on the harmful effects of ionizing radiation.

Prior knowledge: students should understand basic concepts of radioactivity and types of radiation.

Scaffolding: distinguish between natural background radiation

and artificial sources and their effects.

Extension: Investigate radiation protection measures and dosimetry (radiation measurement).

Chapter 12: Science Practices

This chapter provides support for the math and science practices skills students will encounter in chemistry. We recommend assigning these for just-in-time delivery when a new skill is encountered. Encourage students to refer to this chapter when needed. Links to relevant activities within this chapter are identified on an activity page. Topics include exploring the principles of designing and carrying out scientific investigations, and the importance of controlled experiments, accurate observations, and reliable data processing. Support is provided on the concepts of variables, accuracy, precision, and the use of models to understand complex systems. This chapter also covers standardized units, mathematical notation, recording and displaying data, and the role of descriptive statistics in summarizing and interpreting scientific data.

Activity 162: The Nature of Science

Use this activity to discuss how science is a way of understanding the world, then introduce concepts like empirical evidence, logical reasoning, and skepticism. Students should understand that scientific knowledge, and therefore what we know about chemistry, has been developed by building on the findings and work of others. Activity 14, Discovering atomic structure, is an example of this. Students may think science follows a linear, step-by-step process but, in reality, it is often non-linear and iterative. Some may believe that scientific theories are just guesses; use this misconception to clarify the difference between scientific theories and hypotheses.

Activity 163: Systems and Systems Models

Students explore the concept of systems and models and their usefulness in understanding scientific concepts. Explain that models are simplified representations that help us understand complex systems and that they may focus on just one part of the system. Discuss the differences between open, closed, and isolated systems.

Scaffolding: discuss models that are already familiar to students.

Extension: have students create their own models of chemical systems.

Activity 164: Investigations in Chemistry

This activity provides an overview of key considerations when designing a chemistry investigation. Ensure students understand the importance of conducting controlled experiments, and that they understand the difference between independent, dependent, and controlled variables. Chemistry can be daunting, so the analogy of cooking is chemistry provides an accessible starting point for most students.

Prior knowledge: students should understand basic lab safety and equipment use, refer to chapter 1 if necessary.

Scaffolding: the bread making example provides a starting point for learning how to make valid observations.

Literacy: encourage students to write detailed observations, focusing on clear communication of methods and results.

Activity 165: Observations and Inferences

This activity could be used prior to any investigation that requires observations. Ensure that students use the glossary to obtain clear definitions so they accurately distinguish between observation and inference. Emphasize that observations are directly perceived, while inferences are conclusions drawn from observations. Discuss the importance of well documented observations in science.

Scaffolding: start with simple, concrete examples of observations, then introduce the concept of inference.

Extension: students could analyze scientific papers to identify observations and inferences made by researchers.

Activity 166: Accuracy and Precision

Investigations requires students to obtain results that are both accurate and precise. For students who are having trouble differentiating the terms, the simple golf analogy in this activity explains the two clearly. It is common for students to report results to levels they have not accurately been able to measure. Highlight the use of significant figures and how to use them for meaningful reporting.

Prior knowledge: students should understand basic measurement techniques and units.

Extension: investigate how scientists determine and improve the accuracy and precision of their measurements.

Activity 167: SI Units and Measurement

This activity exposes students to the use of SI units (International System of Units). Discuss the use of different measurement systems globally. Some may believe that unit prefixes (kilo-, milli-, etc.) are units themselves. Clarify that prefixes modify existing units.

Prior knowledge: students should be familiar with basic units of measurement.

Scaffolding: start with the seven base SI units, then introduce derived units and unit conversions.

Extension: explore the history of measurement systems and why SI units were developed.

Literacy: encourage students to practice writing and interpreting measurements using correct SI notation.

Activity 168: Working with Numbers

Encourage students to refer to this activity whenever any of these mathematical skills are required. It covers mathematical notation and how to carry out simple calculations and conversions. Students will find the support for rearranging equations and using fact family triangles invaluable. Emphasize the importance of understanding the underlying concepts of rearranging equations over memorization.

Prior knowledge: students should have a strong foundation in basic algebra.

Scaffolding: begin with simple calculations and unit conversions, then progress to more complex problem-solving using dimensional analysis as a problem-solving tool in chemistry.

Activity 169: Graphing Skills

Students often forget the rules for producing accurate graphs, so this activity can serve as a reference whenever a graphing skill is needed. Work through the "How-to" guides for line and scatter graphs before students apply these skills in other activities. Emphasize the importance of choosing the correct graph type and scale to accurately represent the data.

Prior knowledge: students should understand basic coordinate systems and data plotting.

Extension: have students analyze and interpret graphs from scientific literature.

Literacy: encourage students to practice describing trends and relationships shown in graphs using scientific language.

Activity 170: Describing Data

Descriptive statistics provide a way to summarize scientific data and measure central tendency. Differentiate between mean, median, and mode and when to apply them. Use the visual representations to show distribution and skew of data.

Prior knowledge: students should understand basic concepts of averages and data sets.

Extension: explore how descriptive statistics are used in real scientific studies.