MODEL TEXTBOOK OF CHEMISTRY

Based on National Curriculum of Pakistan 2022-23

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A Textbook of Chemistry
for Grade 9

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First Edition - First Impression

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Preface

learning experience. It features high-quality pictorial representations, real-life applications, and experimental skills. The book includes high-order thinking exercises, skill sheets for testing understanding, group activities, and recorded video lectures with animations and simulations. It is structured to aid teachers in creating assessment questions based on Bloom's Taxonomy. At the end of the book, a comprehensive glossary provides quick term references. This educational tool aim s to enrich students' knowledge and appreciation of Chemistry. Thiss Grade 9 Chemistry textbook, aligned with the 2023 curriculum, is designed to enhance students'

The QR codes in the Chemistry textbook provide easy access to video lectures for gaining knowledge and skill sheets for practical application. They make learning more interactive, letting students watch lectures and practice skills right when they need them, making studying chemistry more engaging and effective.

What inside this QR Cord

- Model video lecture of relevant knowledge along with ppts simulations and 3D animations
- Updated research related to knowledge
- Work sheets plus Skill sheets
- Slo based question bank
- Answers to all numerical and self-test questions are accessible through the relevant QR code.

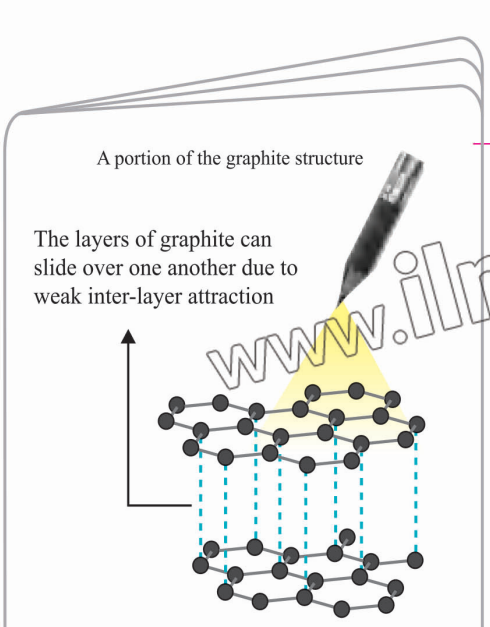
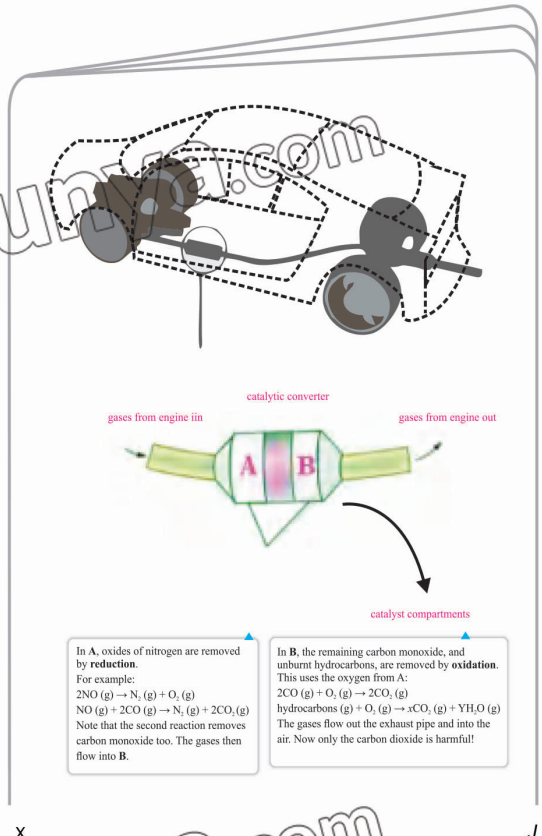


Fig 2.10 Graphite is a carbon-based material with high electrical conductivity. Its unique properties come from the free electrons that become delocalized. The layers of graphite can slide over one another due to weak inter-layer attraction, but the covalent bonds are strong making it have a high melting point.

Diagrams in a chemistry textbook create strong mental images that stick with students, making it easier to remember and understand complex information quickly. These visuals serve as powerful memory aids, reinforcing concepts in a way that stays in students' mind for a long time.



Real life examples in a Grade 9 chemistry book help us see how chemistry applies to the world around us. They make learning more interesting and show us how important chemistry is in our daily lives.

SLO based Model Video lecture

Salient Features

Comprehensive Learning
Engage students with videos, simulations, and practical worksheets.

Structured Lesson Plan
Well-organized with clear objectives, PPTs, and a question bank.

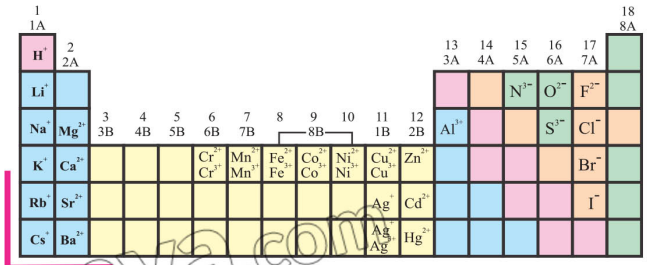
Engaging Multimedia
Visual appeal through PPTs and interactive simulations.

Assessment & Tracking
Diverse question bank and progress monitoring.

Adaptable & Accessible
Scalable and accessible, suitable for all learners.

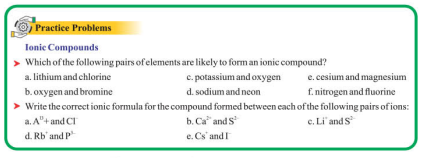
Simulation

SLO:C09 B45
Deduce the formula and name of a binary compound from ions given relevant information.



Power Point Presentation

Knowledge



Practice Problems

Ionic Compounds

- Which of the following pairs of elements are likely to form an ionic compound?
  a. lithium and chlorine c. potassium and oxygen e. cesium and magnesium
  b. oxygen and bromine d. sodium and neon f. nitrogen and fluorine
- Write the correct ionic formula for the compound formed between each of the following pairs of ions:
  a. A^{2+} and Cl^- b. Ca^{2+} and S^{2-} c. Li^+ and S^{2-}
  d. Rb^+ and P^{3-} e. Cs^+ and I^-

Question Bank

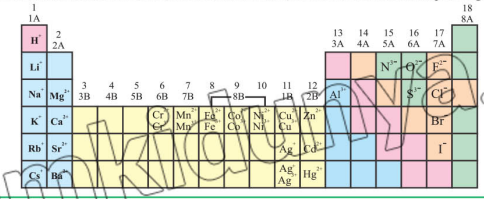
5.1 Knowledge

Chemical Formula Fundamentals

Let's explore the art of writing chemical formulas for both molecular and ionic compounds. With this knowledge, you'll be able to easily generate formulas from any given information. Are you ready to master this skill? Let's get started!

Further Reading — relationship between the periodic table and the charges exhibited by elements

As we discuss in previous chapter The elements in groups 1, 2, and 3 have a tendency to lose one, two, and three electrons, respectively, when forming ions. This is because they strive to achieve the same number of electrons as the nearest noble gas, like Na^+ and Mg^{2+}. By shedding electrons, they attain this desired number. K^+, Ca^{2+}, and Sc^{3+} are similar in that they have 18 electrons, just like the nearest noble gas, argon. The elements in group 13 follow suit and lose three electrons to form cations, like Al^{3+}. In this way, they also achieve the same number of electrons as the noble gas closest to them on the periodic table. The most common ion formed by lanthanides and actinides, formally grouped as 3, is M^{3+}, with M representing the metal. On the other hand, the elements in groups 17, 16, and 15 tend to gain one, two, and three electrons, respectively, when forming ions. This leads to the formation of monatomic ions, like Cl^-, S^{2-}, and P^{3-}, which contain only one atom. You can predict the charges of most monatomic ions derived from the main group elements by looking at the periodic table. Simply count how many columns an element lies from the extreme left or right. For example, Barium (in Group 2) forms Ba^{2+} to have the same number of electrons as its nearest noble gas, xenon. Oxygen (in Group 16) forms O^{2-} to have the same number of electrons as neon. Similarly, cesium (in Group 1) forms Cs^+ to have the same number of electrons as xenon further below you'll find a table that shows different elements grouped according to their charges. However, this method is ineffective for most of the transition metals, but we will delve into this topic in higher classes.



Determining Formulas and Names of Binary Ionic Compounds

Binary ionic compounds consist of two elements a positively charged metal cation and a negatively charged non-metal anion. These compounds are created by the transfer of electrons from the metal to the non-metal, resulting in ions that are held together in a lattice structure by strong electrostatic forces. The overall charge of the compound is neutral, as the total positive charge of the cations is balanced by the total negative charge of the anions. To determine the formula of a binary ionic compound, we use the charges of the metal and non-metal ions to achieve electrical neutrality by balancing the required ion ratio. The table 5.3 below lists the common ions along with their charges.

Test yourself

Identify the branch of chemistry that is related to the following information:

- Starch synthesis in plants illustrates the anabolic reactions in organic chemistry.
- The Bronsted-Lowry theory provides a framework for acid-base reactions in analytical chemistry.
- Iron oxidation exemplifies redox reactions studied in inorganic chemistry.

Reaction rates are explained by

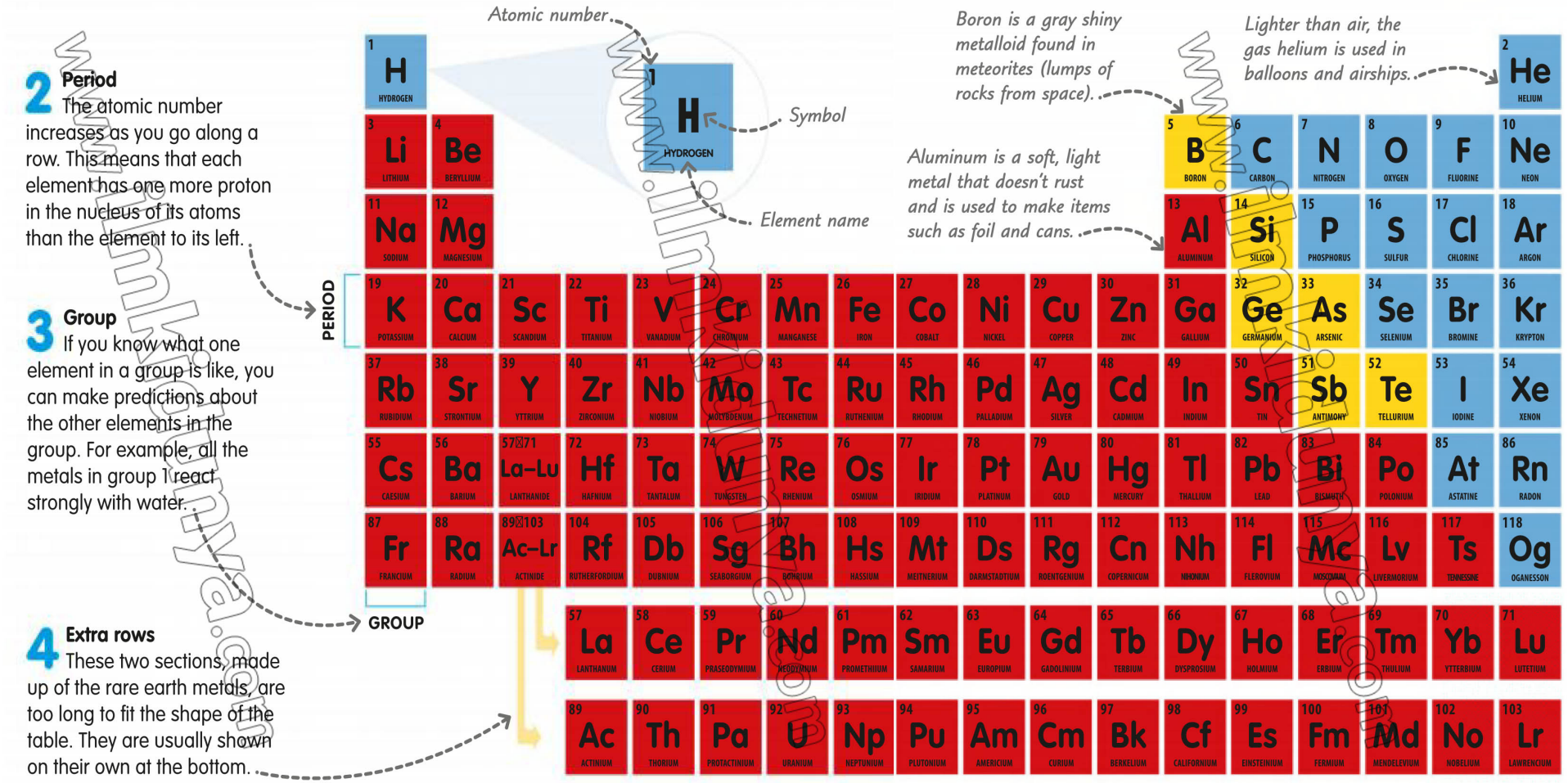
Work sheet

Skill Sheet

The periodic table

The periodic table is a chart of all the chemical elements known to science. They are arranged in order of their atomic number the number of protons in their atoms.

1 Element
Each box gives information about an element, including its name, chemical symbol, and atomic number



2 Period
The atomic number increases as you go along a row. This means that each element has one more proton in the nucleus of its atoms than the element to its left.

3 Group
If you know what one element in a group is like, you can make predictions about the other elements in the group. For example, all the metals in group 1 react strongly with water.

4 Extra rows
These two sections, made up of the rare earth metals, are too long to fit the shape of the table. They are usually shown on their own at the bottom.

KEY

METALS

Most elements are metals. Generally, they share similar properties they are strong, have a shiny appearance, conduct heat and electricity, and can be shaped without breaking.

METALLOIDS

Metalloids, which we also call semimetals, have properties of both metals and nonmetals. Some metalloids partially conduct electricity, and are used in calculators and computers have a shiny appearance, conduct heat and electricity, and can be shaped without breaking.

NONMETALS

Most nonmetals are solid and share similar properties—they are dull, conduct heat and electricity poorly, and are brittle when solid. Some of them are very reactive, such as fluorine (F) and oxygen (O). Eleven of the nonmetals are gases. The gases in the group that starts with helium (He) are the least reactive of all the elements. and nonmetals. Some metalloids partially conduct electricity, and are used in calculators and computers have a shiny appearance, conduct heat and electricity, and can be haped without breaking.

CONTENT

CHAPTER 1

Nature of Science

The development of COVID-19 vaccines showcases the power of science and technology, as researchers used cutting-edge techniques like mRNA to rapidly create effective vaccines. This achievement underscores the importance of scientific research and vaccines in combating public health emergencies and infectious diseases.

Curious why bouncy balls bounce or flames dance? Wonder how food fuels you? Chemistry, the science of matter and change, holds the answers! This chapter is your first step into this exciting world. Imagine exploring tiny atoms, shaping medicines, and designing cleaner energy! Through different branches of chemistry, you will unlock the secrets of our universe, one intriguing molecule at a time. Are you ready? Let us begin!

Students' Learning Outcomes

- Differentiate between 'science', 'technology' and 'engineering' by making reference to examples from the physical sciences.
- Define chemistry as the study of matter, its properties, composition, and interactions with other matter and energy.
- Explain with examples that chemistry has many sub-fields and interdisciplinary fields. (Some examples include: Biochemistry, Medicinal Chemistry, Polymer Chemistry, Geochemistry, Environmental chemistry, Analytical chemistry, Physical chemistry, Organic chemistry, Inorganic chemistry, Astrochemistry.
- Formulate examples of essential questions that are important for the branches of Chemistry(e.g. for Analytical Chemistry a question would be 'how can we accurately determine the chemical composition of a sample?')
- Explain the scientific method to solve the scientific problems.

All the above mentioned SLOs are classified into knowledge and skills for the better understanding of students.

After studying this Unit, the students will be able to understand:

Knowledge

Knowledge 1.1: Science, Technology and Engineering

- Differentiate between 'science', 'technology' and 'engineering' highlighting their specific role in science.

Knowledge 1.2: Chemistry and its domains

- Define chemistry as a field to explores matter's properties and interactions across disciplines like biochemistry and environmental chemistry, addressing crucial questions from drug design to pollution control, embodying the essence of scientific inquiry from molecular to global scales.

Knowledge 1.3: How science work?

- Explain the scientific method as a systematic approach to solving scientific problems, involving steps such as observation, hypothesis formulation, experimentation, data analysis, and conclusion drawing.

Skills

Skill 1.1:

- Demonstrate the ability to differentiate between science, technology, and engineering by providing examples from the physical sciences

Skill 1.2:

- Evaluate the significance of each sub-field of chemistry by formulating essential questions that highlight key inquiries within each branch.

Skill 1.3:

- Apply the scientific method to hypothetical scenarios or real-world problems in chemistry, demonstrating proficiency in designing experiments, analyzing data, and drawing evidence-based conclusions.

Student Learning Outcomes

Differentiate between science, technology and engineering by making reference to examples from the physical sciences.

Update Yourself

Activities in 'Science'

Develops theories, conducts experiments, collects data, analyzes results, and communicates findings

Update Yourself

Activities in 'Technology'

Designs, develops, tests, and implements tools, devices, and processes

Update Yourself

Activities in 'Engineering'

Designs, analyzes, builds, tests, and maintains systems and structures

Think of it this way

Imagine discovering a new star (science). Then, designing a telescope to study it further (technology). Finally, building the telescope and using it for observation (engineering).

1.1 Knowledge

Science, Technology and Engineering

The world of knowledge is very vast where science, technology, and engineering co-exist within these shared boundaries. Let us explore their unique approaches.

Science-The explorer

Science is the systematic study of the natural world through observation, experimentation, and the formulation of theories to understand and explain natural phenomena.

For example, Galileo Galilei did not simply build a telescope (technology); he used it to observe celestial bodies, leading to groundbreaking discoveries about planetary motion (science). Other examples include:

- Observing the stars to understand the formation of galaxies (Astronomy).
- Experimenting with chemicals to explain how they react (Chemistry).
- Analyzing light waves to discover their properties (Physics).

Technology- The Inventor

While science unveils the "how" and "why", technology embodies the "what can be". It is the application of scientific knowledge to create practical solutions and innovations. Skilled engineers transform scientific knowledge into tangible tools and applications. They design, develop, and test these innovations, constantly refining them to improve our lives.

For example, based on the understanding of electromagnetism (science), engineers developed MRI machines, revolutionizing medical imaging technology. Other examples include:

- Building telescopes to study distant galaxies based on astronomical knowledge.
- Developing new medicines based on our understanding of chemical reactions.
- Creating lasers based on the science of light behavior.

Engineering-The Problem-Solver

Engineering is the application of scientific and technological knowledge and mathematical principles to design and build systems, structures, devices, and processes that address specific problems or meet desired objectives.

For Example:

- Designing a spacecraft to reach Mars based on astronomical and physical principles.

- Building bridges using scientific understanding of materials and forces.
- Developing solar panels to harness energy based on principles of light and electricity.

Table 1.1 Key Differences between science, technology and engineering

Aspect	Science	Technology	Engineering
Focus	Science is about understanding.	Technology is about application.	Engineering is about problem-solving.
Process	Science uses observation and experimentation.	Technology uses design and development.	Engineering uses analysis and building.
Output	Science generates knowledge.	Technology creates tools.	Engineering builds solutions.

Conclusion

- Science informs technology.
- Technology empowers science.
- Engineering relies on both.

Skill:1.1

Differentiation between Science, Technology and Engineering

Objective: to help students make informed decisions about their education and clarify their objectives.

Instructions: An activity-based worksheet is attached to the QR code provided at the beginning of this knowledge section. Scan the code, read the worksheet, and complete it.

1.2 Knowledge

Chemistry and its Domains

Scientific knowledge is incredibly diverse. In order to grasp, organize, and effectively advance innovation, scientific knowledge is divided into many branches such as biology, physics, and chemistry, each dealing with a unique aspect of the natural world.

Chemistry is all about the matter that makes up everything around you from your clothes and phone to the air you breathe and the food you eat. It is the science that explores what this matter is made of (atoms and molecules), how it changes (chemical reactions), and why it behaves in the way it does (properties).

The chemists (persons who study chemistry) use experiments and observations to solve mysteries like:

- What happens when baking soda mixes with vinegar? (Hint: it is not just fizzy fun!)
- Why does iron rust? (And, how can we prevent it?)
- How do plants capture sunlight to make food? (It is all about a cool process called photosynthesis!)

However, chemistry is not just about solving mysteries; it is also about creating amazing things! We use our knowledge of chemistry to develop:

- Life-saving medicines that fight diseases
- Sustainable energy sources like solar panels
- New materials with incredible properties, like super-strong plastics or self-cleaning fabrics

Student Learning Outcomes

- Define chemistry as the study of matter, its properties, composition, and interactions with other matter and energy.
- Explain with examples that chemistry has many sub-fields and interdisciplinary fields.

At its core, chemistry involves the exploration of matter and its transformations. It is defined as a field of science that is dedicated to studying matter and its properties, composition, and behaviour when interacting with other substances and energy.

Branches of Chemistry

Chemistry acts like the glue, connecting different areas like biology, physics, and even geology! This is called its interdisciplinary nature. It means we can use chemistry like a bridge to understand things:

- Why plants turn sunlight into food (with biology!)
- How atoms stick together to make different materials (with physics!)
- What makes rocks and minerals unique (with geology!)

However, with so much to learn, chemistry has different branches, like branches of a tree! These branches, like organic chemistry or inorganic chemistry, help us focus on specific areas and tackle complex problems better.

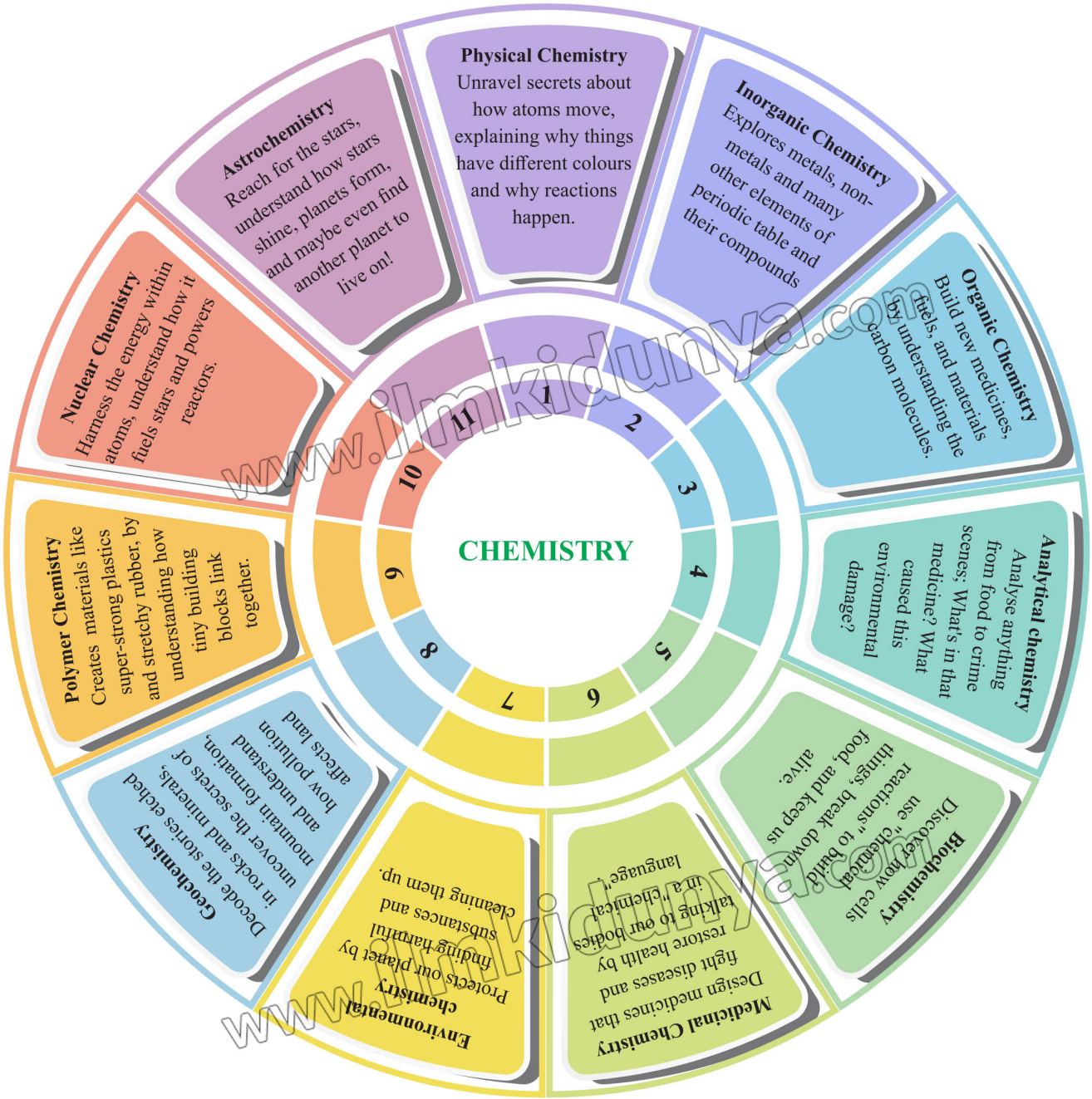


Fig. 1.1 Diverse world of chemistry through its specialised branches

1. Physical chemistry

Physical chemistry is defined as the branch of chemistry that deals with the relationship between the composition and physical properties of matter along with the changes in them. The properties such as structure of atoms or formation of molecules behavior of gases, liquids and solids and the study of the effect of temperature or radiation on matter are studied under this branch.

Some of the key areas of study in physical chemistry include thermodynamics, which is the study of energy and its transformations, quantum chemistry which is the application of quantum mechanics to understand the behavior of electrons in atoms and molecules, chemical reactions, and statistical mechanics which involves the use of statistics to explain the behavior of a collection of particles.

In what field of chemistry is the process of melting discussed? Which is depicted in fig.

2. Inorganic chemistry

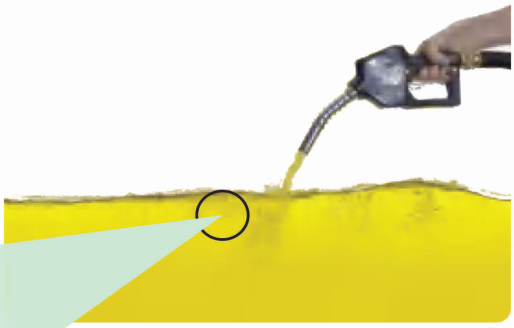
Inorganic chemistry deals with the study of all elements and their compounds except those of compounds of carbon and hydrogen (hydrocarbons) and their derivatives. It has applications in every aspect of the chemical industry such as glass, cement, ceramics and metallurgy (extraction of metals from ores).

Fig. 1.2 A Spectrum of Inorganic Compounds

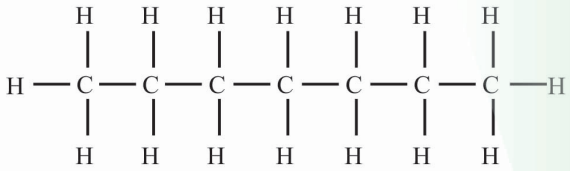
3. Organic chemistry

Organic chemistry is a field of study that focuses on covalent compounds consisting of carbon and hydrogen, known as hydrocarbons, and their derivatives.

Key concepts within this branch include the study of hydrocarbons, functional groups, and the diverse molecules that form the basis of life. Real-world applications are widespread, encompassing pharmaceuticals, agrochemicals, polymers, and the materials essential to life, making organic chemistry foundational to fields like medicine and materials science.



In this figure, gasoline is shown along with its chemical formula. Can you explain why gasoline is an organic compound and how it is used as fuel in automobiles?



n heptane

4. Polymer chemistry: Building Blocks of Materials Science

Polymer chemistry is a field of study that deals with polymers, which are large molecules made up of small repeating units called monomers. The process of linking monomers together to form a molecule of high molecular mass is called polymerization.

Update Yourself

Polymers are sometimes called macromolecules. Can you tell the reason?

There are many different types of polymer (plastics), including polythene, PVC, perspex, teflon and polystyrene. Polymers contain very large molecules, often with hundreds or thousands of atoms. Within each molecule, the atoms are joined to each other by covalent bonds. As shown in Figure 1.3.

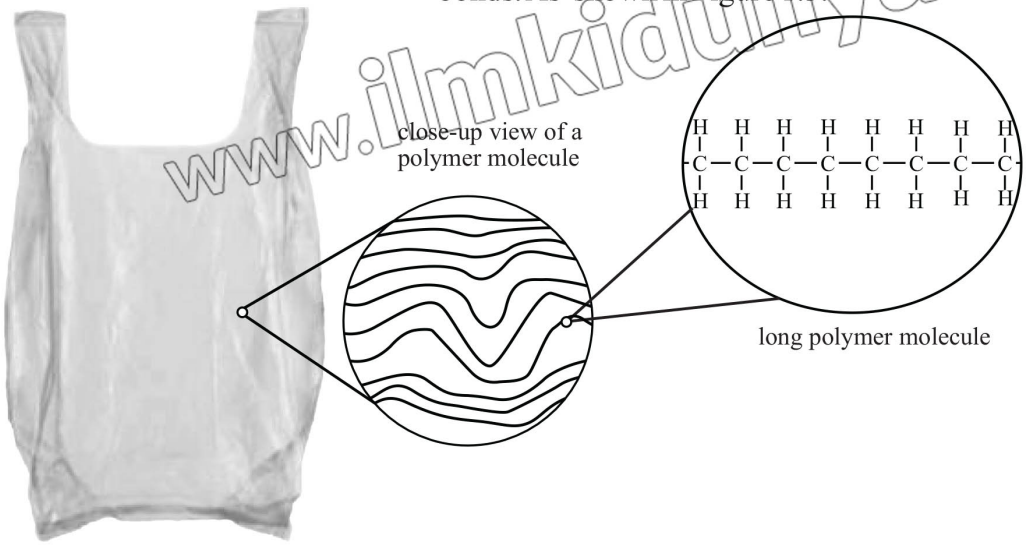


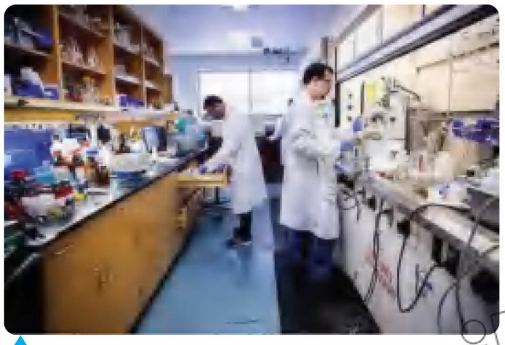
Fig. 1.3 Polythene bag is made up of polymer called polyethen. It is made up of repeatedly joined ethene molecule.

In the picture above, there appears to be a connection between living organisms, specifically plants, and some chemicals. Can you predict which subfield of chemistry this interaction might fall under?

5. Biochemistry

Biochemistry is the branch of science that combines both biology and chemistry to understand and analyze life processes. It focuses on the chemical substances and reactions that occur within living organisms.

It involves the synthesis and metabolism of biomolecules such as carbohydrates, proteins and fats. This field emerged as a separate discipline when scientists began investigating how living things obtain energy from food and how fundamental biological changes occur during a disease. Biochemistry has a wide range of applications in various fields like medicine, food science and agriculture.



Could you make any predictions based on the pictures above regarding the actions performed by the pharmacists?

6. Medicinal chemistry: The Art of Drug Design

Medicinal chemistry is a field where chemists design and build molecules that act as medicines.

They modify existing molecules or create new ones to fight diseases, improve health, and prevent illnesses.

By understanding the weak spots of viruses, like the one that caused COVID-19, medicinal chemists design molecules that can disable the virus, protecting our cells. Vaccines are developed this way. Medicinal chemistry also help create medicines for other conditions like pain relief, diabetes control, and cancer treatment.

7. Analytical chemistry

Analytical chemistry is a branch of science that deals with the study of the composition of matter.

It primarily focuses on identifying, separating, and quantifying chemicals present in various samples of matter. To achieve this, an analytical chemist may use complex instruments to analyze an unknown material and determine its various components. Analytical chemistry plays a vital role in various fields such as science, engineering, medicine, and industry. It helps to solve both qualitative and quantitative problems by providing accurate and reliable results.

Have you recently undergone a medical check-up, during which your doctor recommended a blood test?
Do you to know which branch of chemistry is responsible for dealing with such matters?

8. Environmental xhemistry

Environmental chemistry studies the chemical and biochemical processes in the natural environment like air, water, and soil.

It's a multi disciplinary field that combines several environmental sciences such as geology, biology, ecology, and physics. The goal is to understand the sources, reactions, transport, effects, and fates of chemical species in the environment, including pollutants and contaminants. Its ultimate goal is to develop strategies to prevent or mitigate the negative impact of human activities on the environment while preserving the natural balance of ecosystems.

Can you guess which sub field of chemistry we will discuss major factory issues and how we can control factory smoke from entering the air?

9. Geochemistry: Solving earth chemical mysteries

Geochemistry is a scientific discipline that focuses on the chemical composition of the Earth, including its rocks and beyond our minerals. It also extends planet to encompass the entire Solar System.

The field uses the principles of chemistry to explain the mechanisms behind major geological systems, such as mantle convection and planet formation. Additionally, geochemistry includes the study of the relative abundance, distribution, and migration of the Earth's chemical elements and their isotopes. It is an integrated field that combines both chemistry and geology.

Have you ever wondered what kind of discoveries metallurgical engineer can make during a geological survey?

10. Nuclear chemistry

Nuclear Chemistry is a branch of chemistry that deals with radioactivity, nuclear processes, and properties.

The primary focus of this field is on atomic energy and its applications in everyday life. It involves the study of chemical effects that occur due to radiation absorption in living organisms, plants, and other materials. Nuclear Chemistry has vast applications in

The Karachi Nuclear Power Plant (KANUPP) has a power generating capacity of 1.1GW. The K-3 nuclear unit was built with an investment of $2.7bn and is expected to help alleviate Pakistan's ongoing energy crisis. Can you predict which field of chemistry will be discussed in relation to this project?

— Test yourself

Identify the branch of chemistry that is related to the following information:

- Starch synthesis in plants illustrates the anabolic reactions?
- The Bronsted-Lowry theory provides a framework for acid-base reactions?
- Iron oxidation exemplifies redox reactions studied?
- Reaction rates are explained by collision theory?
- The molecular structure of DNA is a key study area?
- The study of intermolecular forces is essential in understanding states of matter?

various fields such as medical treatment (radiotherapy), food preservation, and generation of electrical power through nuclear reactors, among others.

11. Astrochemistry

Astrochemistry is a branch of science that deals with the study of molecules in space and their reactions. Astrochemists examine the composition of celestial objects (heavenly bodies).

Such as nebulae, which are massive clouds of gas and dust in space. They use advanced tools like telescopes and spectrometers to analyze the light emitted or absorbed by these objects. By doing so, they can determine which elements and compounds are present in the nebula.

Fig. 1.4 "The Helix Nebula is a big cloud of gas and dust in space found in the Aquarius constellation. It's glowing and made up of different kinds of gas, dust, and hydrogen, and elements picture credit from NASA."

—Skill:1.2

Formulation of questions for branches of chemistry

Objective: to help identify key problems or challenges within a particular area of chemistry.

Instructions: An activity-based worksheet is attached to the QR code provided at the beginning of this knowledge section. Scan the code, read the worksheet, and complete it.

1.3 Knowledge

How science work?

In science, it is essential to recognize that the journey of scientific discovery is a structured process. Think back to when you were a child, exploring your surroundings using your senses, touching and tasting things to understand them better. As you have grown, so has your curiosity, leading you to ask questions that are more complex about the world, such as why is the sky blue, where do rainbows come from, or how does lightning form? These childhood wonders are like the stepping-stones that have paved the way for the scientific method,

Student Learning Outcomes

Explain the scientific method to solve the scientific problems.

a systematic approach scientists use to unravel the secrets of the natural world.

In the field of chemistry, the scientific method is a structured process involving several key steps that guide you in exploring and understanding chemical phenomena. These steps are observation, hypothesis, experimentation, and drawing conclusions.

Observation: Ask a question

Does adding baking soda to vinegar actually make it clean faster?

Hypothesis: Propose solution

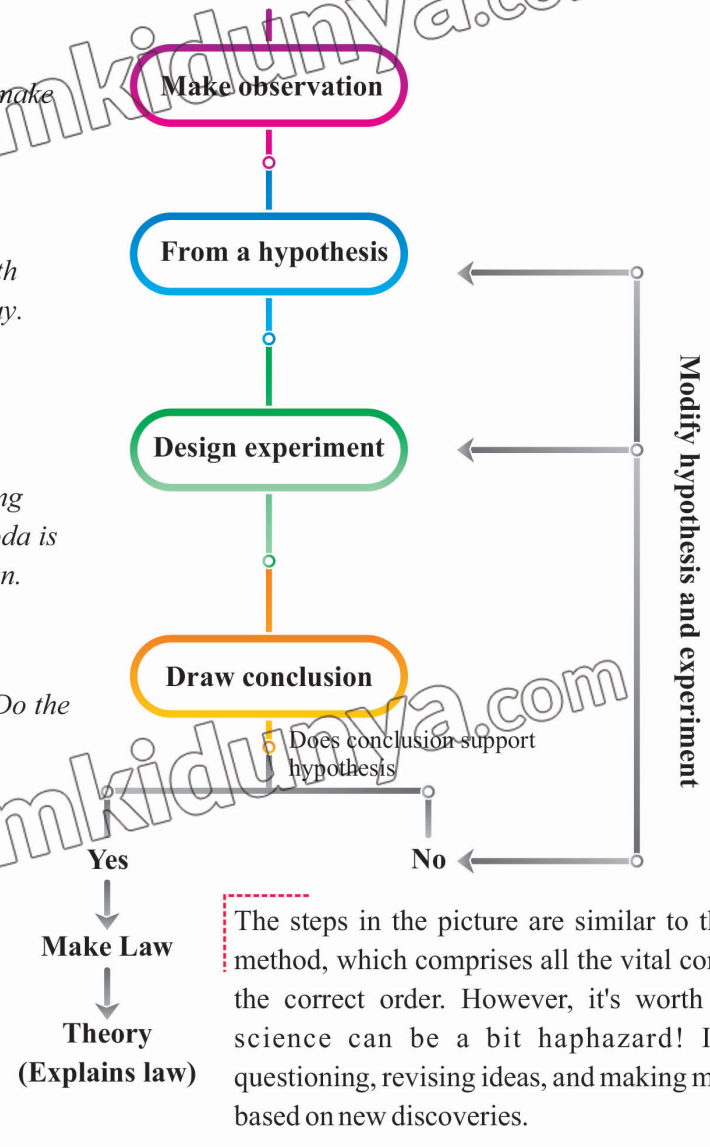
Maybe baking soda fizzes because it reacts with vinegar, creating tiny bubbles that lift dirt away.

Experimentation: Test hypothesis

Mixing different amounts of baking soda and vinegar in separate containers. Keep everything else the same so you can be sure the baking soda is the only 'suspect'. Measure the time of reaction.

Draw conclusions: Analyse and conclude

Analyse your data (cleaning times) carefully. Do the results support your hypothesis? If not, make changes accordingly in hypothesis and experimentation.



The steps in the picture are similar to the scientific method, which comprises all the vital components in the correct order. However, it's worth noting that science can be a bit haphazard! It involves questioning, revising ideas, and making modifications based on new discoveries.

1. Observation

Observation is the starting point. Remember those moments when you observed the colour of the sky changing or noticed the different flavors when you tasted various things? In chemistry, observations involve keenly examining the properties of substances, noting changes during reactions, and using specialized tools to gather data. These observations become the foundation for your scientific exploration.

2. Hypothesis

Based on your observations, what do you think will happen? This guess, called a hypothesis, is your starting point. Maybe baking soda fizzes because it reacts with vinegar, creating tiny bubbles that lift dirt away. In chemistry, a hypothesis is a potential explanation for an observation. It is way of proposing a solution based on existing knowledge. For instance, if you are curious about what makes some materials magnetic, your hypothesis might suggest a connection between certain elements and magnetic properties.

Challange

Identify each of the following as an observation, a hypothesis, an experiment, or a conclusion:

- During an assessment in the emergency room, a nurse writes that the patient has a resting pulse of 30 beats/min.
- Repeated studies show that lowering sodium in the diet leads to a decrease in blood pressure.
- A nurse thinks that an incision from a recent surgery that is red and swollen is infected.

Nurses make observations in the hospital.

Test yourself

Identify each of the following as an observation, a hypothesis, an experiment, or a conclusion:

- Drinking coffee at night keeps me awake.
- I will try drinking coffee only in the morning.
- If I stop drinking coffee in the afternoon, I will be able to sleep at night.
- When I drink decaffeinated coffee, I sleep better at night.
- I am going to drink only decaffeinated coffee.
- I sleep better at night because I stopped drinking caffeinated drinks.

3. Experimentation

Next is putting your hypothesis to the test i.e. experimentation. Just like you might have experimented by mixing different ingredients in the kitchen as a child, in chemistry, experiments involve combining substances, measuring reactions, and carefully recording results. This hands-on approach allows you to explore the behaviour of matter in a controlled setting.

4. Analysing and Drawing conclusions

After conducting experiments and collecting data, you analyze the results to see if they support or challenge your hypothesis. If experimental results indicate that the hypothesis is not valid, it is modified or replaced.

In essence, the scientific method is your guide in the world of chemistry, leading you to explore, question, experiment, and draw meaningful conclusions. As you delve into this exciting journey, keep in mind that each step brings you closer to unlocking the secrets of the substances that make up our universe. Get ready to be a young scientist, ready to tackle the mysteries that lie ahead! Your conclusions contribute not oly to your knowledge but also to the broader scientific community.

Further Reading

Using the Scientific Method in Everyday Life

Did you know that you use the scientific method in your everyday life? Let's say you visit a friend's home and notice that your eyes start to itch and you begin to sneeze. On observing your friend's new cat, you may form the hypothesis that you are allergic to cats. To test your hypothesis, you leave your friend's home. If your sneezing stops, your hypothesis may be correct. You can test your hypothesis further by visiting another friend who also has a cat. If you start to sneeze again, then your experimental results support your hypothesis and you can conclude that you are allergic to cats. However, if you continue to sneeze even after leaving your friend's home, then your hypothesis is not supported. In that case, you need to come up with a new hypothesis, which could be that you have a cold.

Project 1

Materials

Different types of paper towels (e.g., standard, recycled, premium), Water dropper or small bowl of water, Ruler, Stopwatch, Notebook

Experiment Steps:

1. Cut four squares of equal size from each type of paper towel. Label them clearly.
2. Mark a line 1 cm from the edge of each square with a pencil.
3. Place a drop of water in the centre of each square, exactly between the markings.
4. Start the stopwatch immediately. Observe how long it takes for the water to reach the marked line on each square. Record the time in your notebook.
5. Repeat steps 3 and 4 for two more drops of water on each square (total of 3 trials per material).

Question: Which type of paper towel absorbs water the fastest?

Hypothesis: (Choose which material you think will absorb water fastest based on your observations)

Prediction: Explain why you think that material will absorb water the fastest.

Analyze your data by calculating the average absorption time for each material. Did your results support your hypothesis? Explain why or why not.

Challenges

- Investigate the impact of different liquids (e.g., oil, juice) on the same materials.
- Research the science behind absorption and how different materials are structured.
- Design an experiment to test the reusability of different paper towels based on their absorption properties.
- Share your findings with your classmates and discuss the practical applications of your discoveries!

Key Points

- Chemistry is the science of matter and change.
- It explores the composition, properties, and behavior of matter.
- Science systematically studies the natural world through observation, experimentation, and theory formulation.
- Technology applies scientific knowledge to create practical solutions and innovations.
- Engineering uses scientific and technological knowledge to design and build systems, structures, and devices.
- Structured Scientific Method involves observation, hypothesis, experimentation, and drawing conclusions.
- Different branches of chemistry help unlock the secrets of the universe.
- Chemistry connects biology, physics, and geology (interdisciplinary nature).
- Different branches (e.g., organic, inorganic) focus on specific areas to tackle complex problems better.
- Chemistry's scientific method explores the behavior of matter in a controlled setting.
- Organic chemistry studies carbon-containing compounds.
- Inorganic chemistry focuses on non-carbon compounds.
- Physical chemistry applies physics principles to understand chemical systems.
- Analytical chemistry identifies and quantifies substances in various samples.
- Biochemistry explores chemical processes within living organisms.

A detailed summary, chapter roadmap, multiple projects, and extensive exercises are accessible via QR code.

Exercise

A Encircle the most suitable option against each statement.

Note: Answer the questions 1-4 after reading the given scenario.

During a school science fair project, Aisha noticed something strange while growing crystals from different salt solutions. She observed that crystals grown from a copper sulfate solution were a vibrant blue color, while those from a sodium chloride solution were colorless. She decided to investigate further.

1 Which of the following is the MOST appropriate question for Aisha to investigate?

a) Why are crystals blue?
b) Do all salts form crystals?
c) How can we grow the biggest crystals?
d) Does the color of the solution affect the crystal color?

2 Aisha plans to test her hypothesis by growing crystals from solutions with different concentrations of copper sulfate. Which variable should she KEEP CONSTANT?

a) The type of salt used
b) The temperature of the solution
c) The volume of the solution
d) The color of the container

3 After analyzing her results, Aisha finds that the intensity of the blue color in the crystals increases with the concentration of copper sulfate. What is the NEXT step in her investigation?

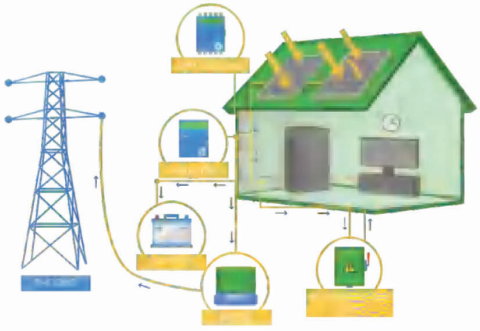
a) Declare her hypothesis proven and present her findings.
b) Repeat the experiment with different types of salts.
c) Investigate the chemical properties of copper sulfate.
d) Design an experiment to explain the mechanism of color formation.

4 Aisha shares her findings with her classmates. Some suggest using different colored salts to see if the crystal color changes. This is an example of:

a) A valid extension of Aisha's investigation.
b) A criticism of Aisha's methodology.
c) An irrelevant observation.
d) A personal opinion on the results.

Note: Answer the questions 5 and 6 after reading the given scenario.

Imagine a solar panel soaking up the sun's rays on a rooftop. Each of these fields plays a part in its existence.



5 Which field discovered the photovoltaic effect, the scientific principle behind solar panels?

a) Technology
b) Engineering
c) Science
d) Mathematics

6 Which field is responsible for designing the structure and integrating solar panels into a functional system?

a) Technology
b) Engineering
c) Science
d) Manufacturing

7 Polymer Chemistry focuses on the properties and uses of large molecules like plastics. An important application of this field is:

a) Dating ancient artifacts
b) Analyzing water quality
c) Developing lightweight materials
d) Predicting the weather

8 Environmental Chemistry aims to minimize pollution and protect our environment. Which of the following is NOT a relevant technique used in this field?

a) Measuring pollutants in air and water samples

b) Developing sustainable energy sources
c) Recycling and waste management
d) Analyzing the chemical content of stars

9 Astrochemistry studies the chemical composition of celestial objects. How does this field contribute to our understanding of the universe?
a) By predicting future weather patterns
b) By developing new medical treatments
c) By understanding the origins of life and planets
d) By improving communication technologies

10 Imagine you discover a new material with unique properties. Which sub-field of chemistry would be most helpful in characterizing its structure and potential uses?
a) Analytical Chemistry
b) Physical Chemistry
c) Organic Chemistry
d) Geochemistry

11 In the scientific method, what is the primary purpose of conducting experiments?
a) To prove the hypothesis
b) To collect data and analyze results
c) To gather anecdotal evidence
d) To establish personal opinions

12 Which of the following steps in the scientific method involves formulating a clear and specific hypothesis based on observations and background knowledge?
a) Analysis
b) Conclusion
c) Hypothesis
d) Experimentation

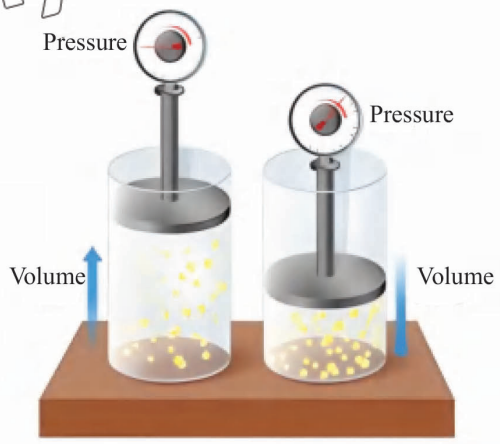
B Answer the following short questions.

1 When does a Hypothesis get accepted as a theory? Give example.
2 Why is the scientific method important?
3 Explain the difference between scientific theory and technological innovation. Use an example from the field of renewable energy generation to illustrate your answer.
4 Differentiate between 'science', 'technology' and 'engineering' by making reference to examples from the below given example.
5 Define the following branches of chemistry: Physical chemistry, Polymer chemistry, organic chemistry
6 There are two branches of chemistry categorised into chemistry of life. Name these branches. Give reason for your answer.
7 Define nuclear chemistry. How it is different from the branches designated as 'chemistry of life'?
8 Draw a self-explanatory flowsheet diagram showing the sequence of stages of scientific method.
9 What are the qualities of a workable hypothesis?
10 Differentiate between the fields of "organic chemistry" and "inorganic chemistry" based on the type of matter they primarily study.
11 Compare and contrast the roles of science, technology, and engineering in addressing environmental issues. Provide specific examples related to Environmental Chemistry.
12 You are a forensic chemist investigating a crime scene. You find a white powder at the scene and need to determine its identity. Which branch of chemistry would you use to identify the powder? Give reason.

C Answer the following questions briefly.

1. Explain the scientific method, emphasizing its key stages such as observation and hypothesis. Additionally, provide a definition for the term 'law' and elucidate the circumstances under which a law is established in the field of chemistry.

2. Here is a diagrammatic representation of a famous law in chemistry known as: Boyle's law:



The law states that: *When the temperature of a gas is held constant, the pressure exerted by the gas is inversely proportional to its volume.*

A students studies the law as an example of scientific method. He has made an observation:

Gases shrank when squeezed, expanded when released.

Your task is to extend his study by:

a. Deducing hypothesis

b. Designing an experiment to test the hypothesis

3. Differentiate between 'science', 'technology' and 'engineering' by giving suitable examples.
Write a note on geochemistry and biochemistry.

4. Explain "chemistry' as a diverse field of science. Discuss the nature of the field, its relation with other discipline as well as role to solve the problems with the help of suitable examples.

D Assertion – Reason type questions

In each of the following questions, two statements are given, one labelled as Assertion (A) and the other as Reason (R). Examine the statements carefully and mark the correct answer according to the instructions given below:

a) If both A and R are correct and R is the correct reason for A

b) If both A and R are correct but R is not the reason for A

c) If A is correct and R is wrong

d) If A is wrong and R is correct

1. **Assertion (A):** Studying the properties of light using prisms is an example of science.
Reason (R): Science focuses on understanding the natural world through observation and experiments. ☐

2. **Assertion (A):** Designing a bridge that can withstand strong winds is an example of engineering.
Reason (R): Engineering considers both scientific principles and practical constraints to create solutions. ☐

3. **Assertion (A):** Studying the reactions between drugs and the human body belongs to medicinal chemistry.
Reason (R): Medicinal chemistry applies chemical principles to design and develop new drugs. ☐

4. **Assertion (A):** Understanding the formation of stars requires knowledge of both chemistry and physics.
Reason (R): Astrochemistry is an interdisciplinary field that combines chemistry and astronomy. ☐

5. **Assertion (A):** "How can we measure the trace amounts of heavy metals in food?" is an important question for analytical chemistry.

Reason (R): Analytical chemistry develops methods to detect and analyze the composition of samples. ☐

6. **Assertion (A):** Observing a new chemical reaction requires designing an experiment to test its properties.
   Reason (R): The scientific method relies on experimentation to confirm observations and draw conclusions. ☐

7. **Assertion (A):** A scientific theory is always accepted as absolute truth.
   Reason (R): Theories are continually tested and refined as new evidence emerges in the scientific method. ☐

8. **Assertion (A):** Communicating research findings in scientific journals is crucial for peer review and future research.
   Reason (R): Sharing results allows other scientists to validate and build upon existing knowledge. ☐

Sample Problem 1

Scientific Method: Thinking Like a Scientist

Identify each activity, "a to f", as an observation, a hypothesis, an experiment, or a conclusion. At a popular restaurant, where Imran is the head chef, the following occurred:

a. Imran determined that sales of the house salad had dropped.

b. Imran decided that the house salad needed a new dressing.

c. In a taste test, Imran prepared four bowls of sliced cucumber, each with a new dressing: sesame seed, olive oil and balsamic vinegar, creamy Italian, and blue cheese.

d. Tasters rated the sesame seed salad dressing as the favorite.

e. After two weeks, Imran noted that the orders for the house salad with the new sesame seed dressing had doubled.

f. Imran decided that the sesame seed dressing improved the sales of the house salad because the sesame seed dressing enhanced the taste.