NATIONAL CURRICULUM 2023

CHEMISTRY CURRICULUM

SUGGESTED GUIDELINES

GRADES 9-12

Pedagogical Principles

The purpose of this curriculum is to both train students in theoretical and experimental skills, while releasing their scientific imagination and instilling in them scientific critical consciousness. Every class has a different dynamic, and different cultures have different norms about the relationship between teachers and students. This curriculum celebrates this diversity, and makes an effort to make it a chief strength. Teachers know their contexts best, and this curriculum does not try to enforce a rigid teaching model. However, there are four principles that are great guides for success:

- **Dialogue:** In order to inculcate scientific critical consciousness, earnest, respectful dialogue in a warm environment is important. Teachers should make every effort to ensure that students have a voice, and are able to express their views on critical issues. Such an environment is key to encouraging earnest self-reflection, and nurturing receptivity to different points of view. Teachers should present ideas in this curriculum as being open to debate and the understanding that our views about science and its impact in the world are never simply ‘neutral’, but are influenced by the narratives we are most familiar with.

- **Inclusive Classrooms:** Classes should be conducive to the learning of all students, regardless of any disabilities, to the maximum extent possible. A detailed guide on differentiating for students with disabilities is provided in the Appendices section. For all students, information should be presented in more than one form (i.e. through a combination of mediums such as multimedia, lecturing, lab demonstrations etc.), and they should be allowed to demonstrate their understanding in more than one way (i.e. not just through written tests, but also through presentations, project work, class conversation etc.).

- **Build on Existing Knowledge**: Each student has their own prior experiences and existing knowledge base, which should be incorporated into teaching by building upon them. This will not only help with learning, but also help students from marginalised identities feel that science is something they can relate to and fully participate and excel in.

- **Hands-on Learning**: Scientific concepts should, to the maximum possible given resource constraints, be taught through structured hands-on experience and experiments with the phenomena being studied. Modeling socio-scientific issues through activities such as role play and presentations in front of community leaders are also very effective in helping inculcate scientific critical consciousness, and in motivating students to take social action.

Classroom Assessment Guidance

Teachers are encouraged to use a variety of methods to assess student learning. These should include both formative (ongoing; in every class) and summative (at the end of each topic or a group of topics) assessments. It is important to emphasize here that, as this curriculum values inclusive education, that students should be given opportunities to demonstrate their understanding through different mediums as well (e.g. through a combination of writing, speaking, artistic expression, project work etc.).

Formative Assessment: In each class, teachers should gauge how students are doing through their participation in class and their engagement and performance with class work. In order to assess their developing critical consciousness skills, in addition to a combination of other mediums, it might be good to have students keep a reflection journal which they spend 5 minutes at the end of class writing in. The learning experience bank in the Appendices section can all be used as means of formative assessment, since they allow for many quality opportunities to observe students as they gauge with the materials, and to even create work portfolio.

Summative Assessment: Teachers should also regularly formally assess students after covering an appropriate number of topics. Assessment does not have to be a written test, rather assessment should ideally be an educational experience in and of itself as well. Performance tasks are assessments that involve students carrying out tasks that mirror how they would be expected to use what they have learned in the real world. For example, the integrative project is a performance task as it requires students to convey an argument about a socio-scientific issue to an actual external audience. An activity that they are likely to repeat in future in one job or another.

Formative Assessment Plan

The learning activities given in the Curriculum Guide can be used as formative assessments to gather evidence of student learning and give students the opportunity to measure their own growth and reflect and articulate key ideas. Here is a sample formative assessment plan that can be adapted by teachers, consisting of multiple assessment strategies. Teachers can pick a few from these for each unit that they cover.

1. **Pre-assessment:** Before starting a new topic, administer a pre-assessment to gauge students' current understanding and identify areas where they may need extra support. This can take the form of a diagnostic quiz, exit ticket, or quick poll.
2. **Classroom Discussions:** Encourage students to participate in regular class discussions, either in small groups or as a whole class. Ask questions, listen to students' responses, and provide feedback on their understanding. These discussions provide an opportunity to check for understanding, encourage critical thinking, and identify areas where students need further clarification.

3. **Quizzes:** Give quizzes or short assessments on the material covered in class. These can be conducted either once or twice within a unit to assess individual student's understanding of the mathematical ideas across lessons. These quizzes should consist of different types of questions that assess different levels of cognitive demand to push students to think, create, connect, and analyze. A rubric can be provided to students with the quizzes and can be used by the teacher to assess these quizzes. The scores will help inform what misconceptions the students have, or what area they lack a proper understanding of, so that the teacher can revise or revisit them during the unit.
4. **Group project:** Occasionally, at the end of a unit, students can be given group projects that require them to apply their knowledge and work together to solve problems. For example, one project might consist of presenting and comparing the three ways to solve systems of equations. Provide the students a rubric before assigning each project and make sure they understand it. Halfway through the project, ensure that the students use the rubric to check their progress. Then use the rubric to score the projects after they have completed them, and provide them with the scores they earned based on the rubric. Offer them opportunities to earn more points by correcting any mistakes.

Performance Assessment: During the lesson, give students open-ended and authentic tasks to demonstrate their mathematical understanding. These tasks will be either individual assessments or group tasks that will be cognitively demanding but low floor and high ceiling problems that will allow students to apply the knowledge they learnt during the lesson and further their understanding. Do not collect this work but instead monitor what the students are doing. Students can be given a rubric to help them self-assess or peer-assess these tasks.

1. **Classroom observations:** While the students are solving tasks and having discussions within groups, roam around the class observing their written work and listening to their conversations. Use a monitoring sheet with student's names on them to record which student is using which strategy and keep a check of the different ideas that are being formulated. Help direct the students' thinking by asking them questions that will push them to critically think. The notes can then be used to sequence ideas and pick particular students to present strategies to discuss in a whole-class discussion to help all students connect between different ideas.
2. **Science Journals:** Encourage students to reflect on their learning and set goals for improvement by writing them in their journals. Have students answer an open-ended question in a journal (like what did you learn today? Or what questions would you like me to answer tomorrow?) and select a few students to share. Reflection helps students see their progress, identify areas for improvement, and take ownership of their learning.

3. **Gallery walk:** Have students respond to questions about the classroom and respond to the ideas of others. Have students work on different tasks in groups and then create a visual display that summarizes their work and understanding of the topic. These displays can be placed around the classroom and have students walk around and interact with each display. They can ask questions, make observations, and give feedback to their peers using post-it notes. After the gallery walk, lead a discussion to debrief the experience. Students reflect on what they learned from their peers, what they found most helpful, and what areas they still need to work on. Instead of student work displays, myths about a certain topic can also be placed around the classrooms and students asked to walk around and respond to the prompts as a group.
4. **Jigsaw:** Have students work in groups to solve a mathematics problem or concept. Each group is responsible for a specific part of the problem or concept, and then mix students up and have them share their findings and ideas to their new group. This process allows students to practice their problem-solving and critical thinking skills, as well as their ability to collaborate and communicate effectively with their peers. The teacher can observe and listen to the students during the activity, and use the information gathered to assess their understanding of the topic being covered and make any necessary adjustments to their instruction.
5. **Exit Tickets:** At the end of most lessons, have students individually complete and hand in an exit ticket. The exit ticket will consist of 1-3 questions ranging from closed questions to assess student's procedural fluency, open-ended questions to assess student's conceptual understanding, questions similar to the tasks done in class to allow students to apply the knowledge they learnt and questions to have them inform the teacher about any confusions/questions that they might still have. These exit tickets will be used to inform the teacher about individual student's current understandings and help him/her tailor the content of the next lesson to suit the students' needs.
6. **Homework:** Occasionally, give students homework to allow them to practice what they learnt during class. The homework questions will also be tasks that allow a deeper level of thinking instead of closed questions that have only one accurate answer. Students can choose a homework buddy to ask for help with homework assignments and they will be encouraged to identify concepts they are struggling with. Homework might only be given a couple of times in a unit to not overburden students, but it will help students self-assess themselves and revisit the concepts discussed in class. At the beginning of the class following a class where a HW was assigned, have a brief discussion that draws connections across HW problems, talks about the challenges students faced, or asks students the justification behind their solving techniques.

Sample Activities

Note:

1. Different National and International Curricula were consulted while developing the NCP for this subject.
2. The mention of all websites and links, from which content for activities was adapted, will be referenced properly and cited after finalisation of the Curriculum Guidelines.
3. There are certain links given here for videos, websites and documents. All links were checked for authenticity on 7th April, 2023, it has been established that they are valid. Since these are third party links, NCC will not be responsible if they are changed or do not work in the future. NCC is working on creating a repository of information which will be sustainable and accessible, all information from links will be downloaded and made available in due time to avoid this issue in the future.

For the reader of this document

Domain

<table>
<tr><td colspan="2">Standard:

Here the relevant parts of the appropriate standard from the Chemistry Progression Grid will be listed, including the relevant benchmarks under that standard</td></tr>
<tr><td colspan="2">Student Learning Outcomes:

Here only the relevant SLOs from the Progression Grid will be outlined</td></tr>
<tr><td>Knowledge:

Here the main important concepts that students should become familiar with are summarised</td><td>Skills:

Here the main important applications of concepts (whether experimental or in the form of solving analytical problems) that students should become skilled with are summarised</td></tr>
<tr><td colspan="2">Perspectives:

These are some (not exhaustive) suggested (not compulsory) topics/prompts for discussion in classes that help students think more critically and in an interdisciplinary fashion about the chemistry concepts they are learning. Perspectives will not be assessed in any exams; they are only intended to help enrich learning for students.</td></tr>
<tr><td colspan="2">Activities

Here the details of suggested activities for the chosen topic are elaborated on. These activities are not compulsory and they are not meant to be followed rigidly step by step. They are only intended to help inspire teachers to develop engaging lessons that help students unpack the concepts with hands-on learning.</td></tr>
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Suggested Guidelines in line with Learning Outcomes

Grade IX-XII

Domain A: Nature of Science in Chemistry

Standard:

Students will demonstrate an understanding, skill and attitude to deal in the areas of chemistry as an introduction to chemistry.

Student Learning Outcomes:

- Explain with examples that chemistry has many sub-fields and interdisciplinary fields.
- Formulate examples of essential questions that are important for the branches of Chemistry

Knowledge: Students can identify different branches of chemistry. The divisions allow students to choose particular branch of chemistry	**Skills:** Students learn the uses of branches, and what are the career scopes of the respective branches.

Perspectives:

Explore how different branches of chemistry, such as organic chemistry, inorganic chemistry, and physical chemistry, are applied in various industries, such as pharmaceuticals, materials science, and energy. For example, in Pakistan, the pharmaceutical industry heavily relies on organic chemistry to synthesize new drugs and the energy sector relies on inorganic chemistry to improve fuel efficiency.

- Historical Development: Trace the historical development of each branch of chemistry and how it evolved over time. For instance, physical chemistry originated in the late 19th century and was heavily influenced by the development of thermodynamics, whereas biochemistry only became a separate branch of chemistry in the early 20th century with the discovery of DNA.
- Interdisciplinary Nature: Emphasise the interdisciplinary nature of chemistry and how branches of chemistry overlap and interact with each other and with other sciences such as biology, physics, and engineering. For example, physical chemistry provides the foundation for understanding the behaviour of biological molecules, and biochemistry builds upon the principles of organic chemistry.
- The Importance of Units in Scientific Measurements: Understanding the importance of having a standardised system of units for chemical measurements is crucial for accurate communication in the scientific community. In the context of Pakistan, it's important for students to understand the use of units in industrial processes, such as the production of fertiliser, textiles, and pharmaceuticals, and the role that accurate measurements play in the quality control of these products.
- The Historical Development of Units: Throughout history, different civilizations have used different systems of units for measurements, such as the Egyptian cubit or the Roman foot. Understanding the evolution of these systems and the need for a standardised system highlights the role of science in shaping our understanding of the world and the importance of accurate measurements in scientific advancement.
- The Role of Scientific Notation in Chemical Calculations: Scientific notation is a

useful tool for expressing very large or very small numbers in a concise and readable manner. In the context of chemistry, this can be used to represent the amount of a chemical substance, the concentration of a solution, or the energy of a chemical reaction. Understanding the importance of scientific notation helps students to accurately perform calculations and interpret data in chemistry experiments.

Activity#1
Materials
Writing board
Instruction sheet
Chart papers and coloured markers.
Pictures related to branches of chemistry.
Methodology
introduction: Teacher will introduce the classification and branches of chemistry to the students with the help of activity:

Teachers will bring different objects of different colours like orange, red, black and green. Firstly, teacher will ask students to separate all the things according to their colour and then students will be told that the green colour things are related to the bio chemistry, red colour indicates inorganic chemistry.

Instructions: Teacher will give instructions about the activity to the students.

- Students will be divided into groups of 4 or 6, each group will have pictures of related branch of chemistry for example in Industrial chemistry the pictures that clarify the formation of products.
- Teacher will mount a chart paper on the board which will have the same coloured boxes on it and the students will be asked to paste pictures in their relevant colour boxes (Each branch will have a specific colour). It related with Biology like Green plants, Green house effect,
- Then students will name the branches and by using their knowledge they will name the branches with the help of the teacher.
- Students will define branches with the help of pictures.

Assessment of objectives: (specify tools of assessment)

Assessment based on following Criteria:

1. defining the branches.
2. Clarity of concept (accurate positioning of the objects in the boxes).
3. Visibility of chart paper content (Presentation)

Domain B: Physical Chemistry

Standard:
Explain the mole concept and its application in chemical calculations, including stoichiometry.

Student Learning Outcomes:

- State the relative charge and relative masses of a subatomic particles (an electron, proton and neutron)

Knowledge:	Skills: Capable to tell properties of subatomic particles
Students will learn and understand structure of atom and get information about characteristic properties ie charge, atomic mass, relative atomic mass) of subatomic particles	

Perspectives:
Concept of mole,
Avogadro numbers
Mole ratio
Mass -mole conversion
Mole-number particle conversion

Activity # 2

Materials
Writing board
Instruction sheet
Chick peas, white beans and peas/ modelling kit can be used.
balance
Methodology
introduction: Teacher will introduce the term relative mass to the students.
Instructions: Teacher will give instructions about the activity to the students.
Students will be divided into pairs; each pair will have related materials for the activity.
Activity:

1. Each pair will count 12 grains of chick peas and record their mass. They will repeat the same process with 12 white beans and 12 peas by using a balance and record the masses.
2. Repeat step 1 twice again with a different 12 of each of the three.
3. Average the masses for each of the three from steps one and two. In this way, ~~you'll~~ you will be getting an average mass of 6 of each of the three.
4. Determine the relative mass in g of peas, white beans and chick peas using peas as the standard. To do this, divide each of the average masses by the lightest (the peas) which of course gives the lightest a relative mass value of one.
5. Mass out one relative mass in g of each substance (use whole pieces) and count the number of particles in each sample. Record these numbers. put the sample on the balance and add enough whole beans (or grains) to achieve the desired weight.
6. Determine the actual mass in g of one grain of rice, one red bean, and one black bean from the data gathered in the previous steps.

Discussion: They will share their understanding with the class by discussion. For example

what are the strengths and limitations of modelling chemical elements as grains of rice?
How does this experiment act as an analogy for helping us appreciate the concept of relative mass?

Conclusion: Teacher will relate relative masses with the atoms of elements.
Teacher's Notes: Teacher can ask following questions in the next class.

1. If you knew the relative masses of the chick peas, white beans and peas but the actual mass of only one of them, could you determine the actual masses of the other two? Show how.
2. What concept (or numbers) in chemistry do these "relative masses" represent (step 4 above)? We used peas for the standard in this activity; what's the chosen standard in chemistry?

Skills: Thinking skills, inquirers, Time management skill, Analytical skills.

Assessment of objectives: (specify tools of assessment)

- **Assessment based on following Rubric**

- **Rubrics:**
  1. calculating the relative masses of different elements
  2. Clarity of concept
  3. discussion based on relative mass

Domain: Domain B: Physical Chemistry

Standard: Apply the principles of thermochemistry to calculate heat transfer and changes in enthalpy.

Student Learning Outcomes:

- explain that enthalpy change is sum of energies absorbed and released in bond breaking and bond forming
- Calculate enthalpy change of a reaction given bond energy values

Knowledge:	Skills:
Students will get idea of energetics of a reaction and tell about the experimental parameter use to describe the term	**Students can define parameter enthalpy and will be able to calculate it**

Perspectives:
Introduction to thermodynamics
Terms in thermodynamic i.e internal energy, Enthalpy
explain that enthalpy change is sum of energies absorbed and released in bond breaking and bond forming
Calculate enthalpy change of a reaction given bond energy values

Activity # 3
Materials
Writing board
Instruction sheet
Play dough balls and toothpicks
Bond enthalpy sheet
Chart papers and coloured markers.
Methodology
introduction: Teacher will introduce the bond enthalpies to the students.
Instructions: Teacher will give instructions about the activity to the students.
Students will be divided into groups of 4-6, each group will have related materials for the activity.
They will make model of their respective equations (each group will be given different chemical equations) by using play dough beads and tooth pics for reactants and products, they break and make the bonds for products.
They will record the relative bond enthalpies of the reactants and products from the provided data sheet.
Activity: Students will find out number of bonds in reactants and products and write the bond enthalpies in the provided worksheet
Conclusion: After that they will calculate the energies in reactants and products and finally find out the overall change after calculations.
They will write the given equation and enthalpy calculations on their cart papers for presentation.
Group presentation: They will display their chart papers in the class for presentation.

Assessment of objectives: (specify tools of assessment)

- **Assessment based on following Rubric**
- **Rubrics:**
  1. Data tables (accurate calculation of data and tabulation)
  2. Clarity of concept (Finding of accurate bond enthalpy)
  3. Visibility of chart paper content (Presentation)
  4. Conclusion (based on calculations)

Domain: Domain C: Inorganic Chemistry

Standard:

Describe the properties and applications of elements in different groups, including the alkali metals, alkaline earth metals, halogens, and noble gases.

Student Learning Outcomes:

- Analyze the relative thermal stabilities of the hydrogen halides and explain these in terms of bond strengths

Knowledge: student will get insight of bond strength	**Skills: students will be capable of telling which bond is strong or weak.**

Perspectives:

Introduction to concept of group

Number of groups in periodic table

Describe the properties of different groups

Properties of the alkali metals, alkaline earth metals, halogens, and noble gases.

Activity#4

Materials

Writing board
Instruction sheet
Beads and tooth pics/ modelling kits

Methodology

introduction: Teacher will introduce the term relative thermal stabilities to the students.
Instructions: Teacher will give instructions about the activity to the students.
Students will be divided into 4 groups; each group will have related materials for the activity.

Activity:

1. Each group will be provided with the coloured beads (black for carbon, white for hydrogen and other different colours for halogens F, Br, Cl and I).
2. According to the band stability bond lengths and bond strengths were told to students in previous lectures students will make models of methyl halogens.
3. Teacher will explain the importance and stabilities of bond enthalpies to the students to explain how chemicals use the energy during chemical reaction.
4. Students will arrange the alkyl halides according to the thermal stabilities of the compounds.
5. In the end they will make a presentation on chart paper about bond enthalpies and will display it on the soft board in the class.

Discussion: They will share their understanding with the class by discussion by solving bond enthalpy

Conclusion: Teacher will relate relative thermal stabilities of bonds with the halogen positioning and bond enthalpies.
Teacher's Notes: Teacher will have to plan the activity based on prior knowledge and will distribute the instruction sheets to the students before starting the activity.

Assessment of objectives: (specify tools of assessment)

- **Assessment based on following Rubric**
- **Rubrics:**

  1. Defining the relative thermal stabilities
  2. Clarity of concept
  3. discussion based on relative thermal stabilities.

Domain: **Domain B: Physical Chemistry**

Standard: (Chemical Bonding) Students should be able to:
Explain the concept of chemical bonding and describe the different types of bonds, including ionic, covalent, and metallic bonds.
Discuss the factors that affect bond strength, including bond length and bond energy.

Student Learning Outcomes:

- Explain the properties of compounds in terms of bonding and structure
- Interpret the strength of forces of attraction and their impact on melting and boiling points of ionic and covalent compounds.

Knowledge:	**Skills:**
Students will get knowledge about • the properties of different compounds based on the types of compounds (ionic compounds, covalent compounds and giant covalent compounds • type of bonding, properties of ionic and covalent compound • Compare the properties of different compounds • Identify the compounds	**Can identify the bonding** **Why boiling point and melting points of compounds are high or low**

Perspectives:
Why atoms form bond
Inert gas configuration, complete shell configuration
Concept of ionic bond
Concept of covalent bond

Activity#5

Materials
Writing board
Instruction sheet
Table salt, sugar, giant covalent compounds like sand.
China dish, spirit lamp, spatula.
Methodology
introduction: Teacher will introduce the properties of different compounds based on the types of compounds (ionic compounds, covalent compounds and giant covalent compounds should be introduced before this topic) to the students.
Instructions: Teacher will give instructions about the activity to the students.
Students will be divided into 3 groups; each group will have different compounds in terms of their bonding for the activity.
Activity:

1. Each group will be provided with all three compounds and then the teacher will ask them to heat them on a spirit lamp in a china dish until it melts.
2. Students will observe the time taken by the compounds to melt.
3. They will record the time and then they will discuss their properties (melting point) in terms of bonding and structure.
4. In the end they will be given homework to find some more compounds and their properties based on bonding.

Discussion: They will share their understanding with the class by discussion.
Conclusion: Teachers will relate bonding with the properties and explain to the students.
Teacher's Notes: Teacher will have to plan another activity by using some other compounds to explain the boiling points, solubility etc to the students.

Assessment of objectives: (specify tools of assessment)
Assessment based on following Rubric

Rubrics:

Why atoms form bond

How ions are formed

What is cation and anion

Differentiate between ionic bond and covalent bond

Teaching learning Evaluation:

Domain: **Domain B: Physical Chemistry**

Standard:Constructing chemical equations and understanding the balancing of these chemical equations

Student Learning Outcomes:

- Deduce the formula of a molecular substance from the given structure of molecules.

- Deduce the formula and name of a binary ionic compounds from ions given relevant information

Knowledge: students can	**Skills: students can write**
• Get idea of valency **• write chemical formula and chemical equation**	**• chemical formula and chemical equation** **• name of compounds**

Perspectives:
Valency of an atom
Group number and valency of an atom
Concept of chemical formula
Molecular & ionic formula

Activity # 6

Materials
Writing board
Instruction sheet
Modeling kits,
Worksheets with different structural formulas like MgO, CH_4, C_2H_6, C_3H_6, C_6H_6
Methodology
introduction: Teacher will display the chart paper with different molecular formulas on the wall and ask the students to make possible structures out of these formulas.
Activity:
Firstly, Students will use the modeling kit or beads and toothpicks to make different arrangements of the molecules and then they share it with the teacher and find out all possible structural arrangements of the molecular formulas.
Secondly, students (randomly asked by the teacher) will draw the structures of different molecules on the board.
Finally, the teacher will explain some more complex structures and molecular arrangements of some other compounds and homework will be given to find some other molecules and their possible structures.
Teacher's Notes: Teachers will have to plan another activity by using some other compounds to explain the structural formulas of different compounds to the students.

Skills: Communication skills, Time management skills.

Assessment of objectives: (specify tools of assessment)
Assessment based on following Rubric

Rubrics:
Valency of an atom is characteristic property how
Group number and valency of an atom are related how
Write chemical formula of compounds of Ist group and VII group elements
Differentiate between Molecular & ionic formula

Teaching learning Evaluation:

Domain: **Domain B: Physical Chemistry**

Standard: (Electrochemistry) Students should be able to:
Describe the principles of electrochemistry, including the movement of electrons in terms of oxidation and reduction in a chemical reaction.
Explain the concept of oxidation and reduction, including the role of electrons in these processes.

Student Learning Outcomes: Students will be able to identify the reducing and oxidizing agents in a redox reaction in terms of electrons.

- Explain that the sum of the oxidation numbers in a neutral compound is zero
- Define redox reactions as simultaneous oxidation and reduction in terms of oxygen, hydrogen, electrons and changes in oxidation state

Knowledge: Students will get knowledge about	Skills: students will be able to
● the fact that the sum of the oxidation numbers in a neutral compound is zero ● redox reactions as simultaneous oxidation and reduction in terms of oxygen, hydrogen, electrons and changes in oxidation state	● Explain that the sum of the oxidation numbers in a neutral compound is zero ● Define redox reactions as simultaneous oxidation and reduction in terms of oxygen, hydrogen, electrons and changes in oxidation state

Perspectives:
Definition of electrochemistry
Insulator & conductors
Electrochemical reaction
Oxidation number
Describe the principles of electrochemistry, including the movement of electrons in terms of oxidation and reduction in a chemical reaction.
Explain the concept of oxidation and reduction, including the role of electrons in these processes.

Activity # 7

Materials
Writing board
Instruction sheet
Ping pong balls and table tennis rackets
Methodology
introduction: Teacher will introduce the term oxidation and reduction in terms of loss and gain of electrons and oxygen to the students.
Instructions: Teacher will give instructions about the activity to the students.

Students will be divided into pairs; each pair will be provided with the ping pong ball and rackets.

Activity:

- Teacher will explain that the balls represent the electrons and rackets work like atoms
- Each pair will play with the ball and rackets and the teacher will explain that the transfer of electron from one racket to the other is actually like an electron transferring from one atom to the other the racket which will lose the ball is acting like a reducing agent and the racket getting the ball is reduced and acting as an oxidising agent.in other words Reduction is gain of electron and when ball is move against racket it is loss and the ball act as reducing agent with respect to 2nd racket
- Teacher will write a few redox reactions on the board and the students will identify the oxidizing and reducing agents.

Discussion: Students will share their understanding with the class by answering the questions written on the board.

Conclusion: Teacher will explain the oxidizing and reducing agents in terms of the OIL- RIG term. (OIL oxidation is loss and RIG reduction is gain of electrons)

Teacher's Notes: Teacher will have to plan another activity for the next lesson in which the concept of oxidation and reduction given in terms of addition and loss of oxygen, addition and loss of hydrogen to explain the redox reactions.

Skills: Thinking skills, communication skills.

Assessment of objectives: (specify tools of assessment)

Assessment based on following Rubric

Rubrics:

Define oxidation and reduction

Define oxidizing and reducing agent

Give the name elements acting as oxidizing and reducing agent

Teaching learning Evaluation:

Domain B: Physical Chemistry

Standard: (Energetics) Students should be able to: Describe the nature of energy, including energy profile diagrams.
Explain the relationship between energy and chemical reactions, including exothermic and endothermic reactions.
Apply the principles of thermochemistry to calculate heat transfer and changes in enthalpy.

Student Learning Outcomes: Students will be able to draw, label and interpret reaction pathways for exothermic and endothermic reactions.

- Draw, label and interpret reaction pathway diagram for exothermic and endothermic reaction which includes enthalpy change, activation energy (uncatalyzed and catalyzed), reactants and products

- Explain that activation energy depends on reaction pathway which can be changed using catalysts or enzyme (detailed pathways not required)
- Recognize that bond breaking is endothermic and bond making is exothermic processes.
- explain that enthalpy change is sum of energies absorbed and released in bond breaking and bond forming

Knowledge: students get knowledge of	Skills: students can identify
Heat of reaction **Exothermic & endothermic reaction** **Activation energy**	**Endothermic & exothermic reaction** **Define activation energy** **Heat of reaction**

Standard:

Concept of energy

Describe the nature of energy

exothermic and endothermic reactions.

energy profile diagrams, exothermic and endothermic reactions.

Laws of thermodynamics i.e First law of thermodynamics to calculate heat transfer and changes in enthalpy.

Activity # 8

Materials

Writing board

Instruction sheet

Chart papers and colored markers.

Methodology

introduction: Teacher will introduce the term exo and endo to the students.

exothermic and endothermic changes to the students.

Activity:

- Teacher will display a chart paper with two pictures, one of melting ice and the other one of fire.
- Teacher will ask questions about the pictures like
- From which process you will feel heat and which will give a cooling effect.
- Students will give correct answers that fire will give out heat and ice will be felt colder.
- Teacher will draw energy profile diagrams of both the processes and explain it to the students.For example In melting ice, It take energy from surrounding and absorbs energy.
- Students will be provided with a worksheet in which they will have to fill at least one exothermic and one endothermic change from their daily life into two columns. (like photosynthesis is endothermic, condensation is exothermic). Then they will draw energy profile diagrams for both the processes on their worksheets.

Wrap up by the students.

Skills: Thinking and Communication skills

Assessment of objectives: (specify tools of assessment)

- **Assessment based on following Rubric**
- **Rubrics:**

Define Exothermic & endothermic reaction
Give example of Exothermic & endothermic reaction
Define Activation energy

Domain C: Inorganic Chemistry

Standard:(Periodic Table and Periodicity) Students should be able to: Describe the organization of the periodic table, including the arrangement of elements by atomic number, electron configuration, and chemical properties.
Explain the concept of periodicity, including the repeating patterns of physical and chemical properties of elements.
Discuss the trends in the periodic table, including ionization energy, electron affinity, and electronegativity.
Apply the principles of periodicity to predict the properties and reactivity of elements.
Describe the role of the periodic table in the study of chemistry and its importance in the prediction of chemical behaviour.

Student Learning Outcomes: Students will be able to understand the relationships between group number and ion.

- Explain the relationship between group number and the charge of ions formed from elements in the group in terms of their outermost shells
- Explain similarities in the chemical properties of elements in the same group in terms of their electronic configuration
- Predict the characteristic properties of an element in a given group by using knowledge of chemical periodicity
- Deduce the nature, possible position in the Periodic Table and the identity of unknown elements from given information about their physical and chemical properties

Knowledge: students get information about

- **Valency**
- **Relate group number and valency**
- **Elements in group have same chemical properties**
- **Predict the position of elements in periodic table**

Skills: students can identify

- **Valency**
- **Relate group number and valency**
- **Elements in group have same chemical properties**
- **Tell the position of periodic table**

Perspectives:
Classification and arrangement of elements by atomic number, electron configuration, and chemical properties.
Concept of periodicity, including the repeating patterns of physical and chemical properties of elements.
the trends in the periodic table, including ionization energy, electron affinity, and electronegativity.
Apply the principles of periodicity to predict the properties and reactivity of elements.

Describe the role of the periodic table in the study of chemistry and its importance in the prediction of chemical behaviour.
Activity # 9 **Materials** Writing board Instruction sheet Periodic table. Cards with the symbols of elements and their ions at least one from each group. **Methodology** **introduction:** Teacher will display periodic table in the class and explain the arrangement of elements in the periodic table. Arrangement of elements in the groups will be explained. **Activity:** ● Teachers will distribute cards which have symbols of the first 20 elements to the students. ● Teacher will make 8 columns on the board for the activity ● Students will tell the ion formation of the element/s assigned to them on their cards according to the position of the respective element in the periodic table. ● They will write the ion of their respective element on their cards. ● They will show the movement of electron in the elements. ● They will display their cards on the black/white board according to the group to show their ion formation in the periodic table. ● They will tell that why ions will have + ive or – ive signs on the ions. **Wrap up by the students.** **Skills:** Critical thinking and communication
Assessment of objectives: (specify tools of assessment) ▪ **Assessment based on following Rubric** ▪ **Rubrics:** **Give Valency of elements of Group I, II, III, VII of periodic table** **What is Relationship between group number and valency** **chemical properties of ements in group are same why** **Predict the position of elements in periodic table with 8 electron in outermost shell** **Teaching learning Evaluation:**

Domain: Domain C: Inorganic Chemistry
Standard: Discuss the chemical behavior of elements in different oxidation states and their role in chemical reactions.
Student Learning Outcomes: Students will be able to identify the properties of transition

elements; high density, high melting point, variable oxidation states, colored compounds formation.

Describe the transition elements as metals that: have high densities, high melting points, variable oxidation numbers, form colored compounds and act as catalysts for industrial purposes.

(some examples include catalysts being used are the Haber process, catalytic converters, Contact process and manufacturing of margarine)

Knowledge: students can get information about	**Skills:**
the properties of transition elements (ie high density, high melting point, variable oxidation states, colored compounds formation).	**Students can** **Identify the transition elements** **Tell the Properties of transition elements** **Discuss colored compounds**

Standard:
Oxidation state
Oxidation state of H,O, halogens, alkali metal , alkaline earth metal
The chemical behaviour of elements in different oxidation states and their role in chemical reactions.

Activity # 10

Materials
Writing board
Instruction sheet
Beakers containing some transition elements like Iron and its salts Iron II, Iron III, copper and copper II Sulphate, salts of manganese KMnO4, Potassium permanganate, water, empty beakers, glass rod and spirit lamp.

Methodology
introduction: Teacher will introduce the transition elements and their properties by showing the samples in the beakers.

Activity:

- Students will come in pairs to observe the samples and the teacher will explain their properties to them as their properties will make a difference.
- Teacher will show iron and its salts to the students and ask if there is a difference in them and then explain that this is due to variable oxidation states (different colors).
- Students will also observe high density of metals.
- One student will take one of the metals and try to burn it on a spirit lamp in front of the class to show the high melting point of metals.
- Another student from the class will come and make a solution of copper II sulphate which will have blue colour to show coloured compounds.
- In the end students will fill the worksheet with their observations provided to them.

Wrap up by the teacher.
Teacher notes:
Teacher will make a worksheet in which students will write their observations related to the materials provided to them.

Skills: Analytical skills, communication skills.

Assessment of objectives: (specify tools of assessment)

- **Assessment based on following Rubric**

- **Rubrics:**

By checking the correct placement of elements in the worksheet.

Transition elements have Variable oxidation states give at least two example
What is colour of Iron II & Iron III salts

Teaching learning Evaluation:

GRADE 10

Domain A: Nature of Science in Chemistry

Standard: Students will demonstrate an understanding, skill and attitude to deal in the areas of chemistry as an introduction to chemistry.

Student Learning Outcomes:

- Justify, with examples, that to do science is to be involved in a community of inquiry.

Knowledge: students get knowledge about Science i.e social & natural science	**Skills: differentiate between natural science and social science**

Perspectives:
Natural & social science
Application of natural science
understanding, skill and attitude to deal in the areas of chemistry as an introduction to chemistry.

Activity#1

Materials
Writing board
Instruction sheet
Chart papers and coloured markers.
Computer and internet
Methodology
introduction: Teacher will introduce the community and the inquiry upon it with the help of examples.
Instructions: Teacher will give instructions about the activity to the students.

- Students will be divided into groups of 4 or 6, each group will be provided with the reading articles on the above topic (Discoveries)
- Students will read the articles and make points out of it about
  How they discover,
  what are the drawbacks
  what are the struggles
- They will use computers to research about the topic and pick/discuss important points.
- They will make a powerpoint/ presentation
- They will present it in the class They have to explain about their perception of understanding

Wrap up by the teacher,

Skills: Research skills, communication skills, time management skills

Assessment of objectives: (specify tools of assessment)

Assessment based on following Rubric

Rubrics:

1. defining the topic.
2. content used for information
3. Visibility of slides (Presentation)
4. way of presentation.

Teaching learning Evaluation:

Domain: **Domain A: Nature of Science in Chemistry**

Standard: Students will demonstrate an understanding, skill and attitude to deal in the areas of chemistry as an introduction to chemistry.

Student Learning Outcomes: Students will be able to understand scientific model is a theoretical model of how nature work

Explain, with examples, that a 'scientific paradigm' is a theoretical model of how nature works

Knowledge:	Skills:
Understand the Nature Scientific model of how nature works theoretical model of how nature works	**Understand Scientific and** theoretical model of how nature works

Perspectives:
Natural & social science
Application of natural science
understanding, skill and attitude to deal in the areas of chemistry as an introduction to chemistry.

Activity# 2

Materials
Writing board
Instruction sheet
Chart papers and markers, computer with active internet
Methodology
introduction: Teacher will introduce the topic scientific model is a theoretical model of how nature works to the students.
Instructions: Teacher will give instructions about the activity to the students.
Students will be divided into groups; each group will have related materials for the activity.
Teacher will ask few questions
Use of scientific models
Can you name some of the models?
Then teacher will display some information about the model on the board
Like:
Objects that are too small to see is a model of atom or cell
Objects like galaxy that are too big are model of planets/ galaxy
Events that are too fast to see models of earthquakes etc.
Activity:
1. Each group will do research and design a model
2. They will find types of these models and record them
3. They will find and record their models advantages and limitations
4. Students will display their models in the class

Discussion: They will share their understanding with the class and discuss advantages and limitations

Wrap up by the teacher.

Skills: Thinking skills, inquirers, research skills

Assessment of objectives: (specify tools of assessment)

- **Assessment based on following Rubric**

- **Rubrics:**

  1. observing the discussion and presentations.

Teaching learning Evaluation:

Domain B: Physical Chemistry

Standard: (Matter) Students should be able to:
Discuss the behaviour of matter at the macroscopic and microscopic levels, including the kinetic molecular theory and phase changes.

Student Learning Outcomes:

- Distinguish between evaporation and boiling.
- *Explain qualitatively the effect of external pressure on rate of boiling and evaporation*

Knowledge: students Get information about matter macroscopic and microscopic properties kinetic molecular theory to describe behaviour of matter about states of matter and phase changes.	**Skills:** **can define matter** **can tell properties of matter** **can describe phase changes (gases, liquid, solid)**

Perspectives:
kinetic molecular theory of gases
phase changes
Distinguish between evaporation and boiling.
Explain qualitatively the effect of external pressure on rate of boiling and evaporation
macroscopic and microscopic properties
kinetic molecular theory to describe behaviour of matter
about states of matter and phase changes.

Activity#3

Materials
Writing board
Instruction sheet
Syringe with a plunger, rubber cork
Methodology
introduction: Teacher will introduce the topic that how increasing and decreasing the pressure will affect the boiling and evaporation.
Higher Atmospheric Pressure = More Energy Required to Boil = Higher Boiling Point.
It can be explained by an activity.
Instructions: Teacher will give instructions about the activity to the students about pressure

- Students will be divided into groups; each group will have related materials for the activity.
- Teacher will provide syringe water and a rubber cork to all the groups.
- They will half fill the syringe with water which will have an air bubble.
- They will block the front of the syringe with rubber cork and then pull out the plunger to reduce pressure.
- They will observe that the air bubble increases in size and putting back the plunger to its original position will increase the pressure.

- If they pull the plunger for a longer period of time, they will see that the water will start boiling at lower temperature.

Conclusion: After that they will conclude that at lower pressure the boiling point will decrease and at higher pressure the water will boil at high temperature.
Worksheet: Students will answer the following questions.
What is Boiling point?
What is effect of Vapour pressure on boiling point
How atmospheric pressure affect the boiling point
Define Melting point
At sea level the atmospheric pressure is 101.3 kPa and at mars it will be 0.6kPa where water will boil at lower temperature?

Skills: Thinking skills, inquirers, Analytical skills

Assessment of objectives: (specify tools of assessment)

- **Assessment based on following Rubric**
  1. Answer given on the worksheet
  2. Clarity of concept
  3. Conclusion (based activity)

Teaching learning Evaluation:

Domain: **Domain B: Physical Chemistry**

Standard: (Reaction Kinetics) Students should be able to: Describe the nature of chemical reactions including the activation energy and rate of reaction.

Student Learning Outcomes:
- Describe the physical parameters that may be affected by the rate of, reaction including change in mass, temperature, and formation of gas

Knowledge:	**Skills:**
• Get information about • Kinetics • Rate of reaction • Factors (temperature, concentration, catalyst) effect rate of reaction • Activation energy	**Can define** • Kinetics • Differentiate between kinetics & thermodynamics • Rate of reaction • Interpreting the graph to find the rate of reaction. • Effect of temperature, concentration, catalyst on rate of reaction • Activation energy

Perspectives:
Rate of reaction
Factors (temperature, concentration, catalyst) effect rate of reaction

Activation energy
Differentiate between kinetics & thermodynamics
Graph of concentration and time, Interpreting the graph to find the rate of reaction.

Effect of temperature, concentration, catalyst on rate of reaction

Activation energy
Activation energy and temperature

Activity#4

Materials
Writing board
Instruction sheet
Digital balance, cotton plug, calcium carbonate powder and lumps, vinegar/ HCl conical flask, stop watch.
Methodology
introduction: Teacher will introduce the rate of reaction to the students.
Instructions: Teacher will give instructions about the activity to the students.
Students will be divided into groups; each group will have related materials for the activity.
Activity:

1. Each group will be provided with apparatus.
2. Teacher will set up sample apparatus for students.
3. One group will add lumps of calcium carbonate in the conical flask and the other group will add powdered calcium carbonate and they will record the mass on the digital balance and add 50 ml of HCl into the conical flask and plug the mouth of the conical flask with cotton and record the mass loss by switching on the stop watch after every 30 seconds.
4. They will record the mass loss until it becomes constant.
5. After constant weight they will stop the reaction and plot a graph with the help of the teacher.
6. They will compare the rate of reaction of both the reactions by using this graph.
7. They will interpret the rate of reaction in both experiments and compare both the reaction rates.

Discussion: They will share their understanding with the class by discussion.

Teacher's Notes: Teacher will have to plan the activity based on the materials and time taken. It can be extended for the next class in which they can plot the graph.

Skills: Thinking skills, Analytical skills.

Assessment of objectives: (specify tools of assessment)

- **Assessment based on following Rubric**

- **Rubrics:**
- **Kinetics of reaction**
- **Rate of reaction**

Interpreting the graph to find the rate of reaction.

Teaching learning Evaluation:

Domain: **Domain B: Physical Chemistry**

Standard:
Discuss the relationship between electricity and chemical reactions, including the use of electrodes and electrolytes.
Apply the principles of electrochemistry to explain the behaviour of batteries, fuel cells, and other electrochemical devices.

Student Learning Outcomes:

- State that hydrogen-oxygen fuel cell uses hydrogen and oxygen to produce electricity with water as the only chemical product
- Describe the advantages and disadvantages of using hydrogen–oxygen fuel cells in comparison with gasoline /petrol engines in vehicles

Knowledge:	**Skills:**
Students get knowledge of electricity and chemical reactions, electrodes and electrolytes. Understand the principles of electrochemistry behaviour of batteries, electrochemical devices such as fuel cells, dry cell ● Describe the advantages and disadvantages of using hydrogen–oxygen fuel cells in comparison with gasoline /petrol engines in vehicles	Understand the electrochemical cells the advantages and disadvantages of hydrogen–oxygen fuel cells in comparison with gasoline /petrol engines in vehicles

Perspectives:
Electrochemical chemical reactions, electrodes anode cathode and electrolytes.
principles of electrochemistry
electrochemical cells and batteries such as fuel cells, dry cell
hydrogen–oxygen fuel as Example of fuel cell
Describe the advantages and disadvantages of using hydrogen–oxygen fuel cells in comparison with gasoline /petrol

Activity#5

Materials

Writing board
Instruction sheet
Reading material
Chart papers and coloured markers.

Methodology

introduction: Teacher will introduce the hydrogen fuel cell and its application in the class.
Instructions: Teacher will give instructions about the activity to the students.
Students will be divided into 3 groups; each group will have different information about the hydrogen fuel cell for the activity (principle of hydrogen fuel cell construction of the cell and the application of the hydrogen fuel cell).

Activity:

1. Each group will be provided with the reading material and chart paper and markers.
2. Students will read the articles and then pick main points from the reading material to make relevant presentations.
3. They will write the basic information on their chart papers and make a presentation.
4. They will present in front of the class
5. First group will tell about the principles of hydrogen fuel cell
6. Second group give information about the construction of the cell
7. Third group will share the application of hydrogen fuel cells.

Teacher's Notes: Teacher will have to bring relevant reading material for the students. In the end the teacher will give the following questions in the homework.

1. How will fuel cell vehicles differ from the vehicles we use today?
2. Name the three main parts of a fuel cell.
3. What is necessary for a fuel cell to produce electricity?
4. What does a catalyst do?
5. Fuel Cells — How Do Fuel Cells Work?
6. List two advantages of using fuel cell vehicles instead of our current fossil fuel vehicles.

Skills: Research skills, Time management skills, comprehensive skills.

Assessment of objectives: (specify tools of assessment)

- **Assessment based on following Criteria**
  1. Main points in the presentation
  2. Understanding and delivery of the information
  3. Presentation of the work.

Teaching learning Evaluation:

Domain: **Domain B: Physical Chemistry**

Standard: (Reaction Kinetics) Students should be able to

Explain the factors that affect the rate of reaction, including temperature, concentration, surface area, and catalysts.

Student Learning Outcomes:
Describe collision theory in terms of number of particles per unit volume, frequency of collisions of particles, kinetic energy of particles and activation energy

Knowledge: ● Get knowledge of collision between the molecules ● theory in terms of number of particles per unit volume, ● frequency of collisions of particles	Skills: Student will be capable to explain reactions in term of collisions Explain the term related to collision of molecule

Perspectives:

Activity# 6

Materials
Writing board
Instruction sheet
Different colour plasticine/play dough
Methodology
introduction: Teacher will explain the collision theory in the class with the examples of car collisions.
Activity:
- Students will be divided into three groups.
- Firstly, Students will use the plasticine/ play dough to make different atoms or balls of reactants.
- Secondly, one by one students' groups will be called in front of the class
- Finally, First group will collide the balls with low force and will observe the result
- Second group will collide the balls with medium force and will see the result
- Third group will collide the balls with higher force and they will see that the balls which were collided with higher and medium force they merged with each other and converted into new shapes same like an effective collision taking place in a chemical reaction.

Wrap up: Teacher will relate this activity with collision theory to wrap up the lesson.

Skills: Thinking skills, analytical skills.

Assessment of objectives: (specify tools of assessment)
- **Assessment based on following Rubric**
- **Rubrics:**
  By getting feedback on the collision of the balls.

  Getting information about frequency of collisions of particles
  Rate of reaction is proportional to collision Frequency

Teaching learning Evaluation:

Domain: **Domain B: Physical Chemistry**	
Standard: (Reaction Kinetics) Students should be able to: Describe the nature of chemical reactions, including the activation energy and rate of reaction.	
Student Learning Outcomes: ● Describe the physical parameters that may be affected by the rate of, reaction including change in mass, temperature, and formation of gas ● Interpret data, including graphs, for investigating rate of reaction	
Knowledge: get knowledge of ● **factors affecting rate of reaction** ● **Activation energy** ● **Effect of temperature on activation energy** ● **Data interpretation**	**Skills:** **●Can describe the physical parameters that may be affected by the rate of, reaction including change in mass, temperature, and formation of gas** **● Interpret data, interpret the graphs, for investigating rate of reaction**
Perspectives: Rate of reaction Factors (temperature, concentration, catalyst) effect rate of reaction Activation energy Differentiate between kinetics & thermodynamics Graph of concentration and time, Interpreting the graph to find the rate of reaction. Effect of temperature, concentration, catalyst on rate of reaction Activation energy Activation energy and temperature	
Activity# 7 **Materials** Writing board Instruction sheet Salt, sugar, water, powdered sugar, vinegar, baking soda, . Beakers, glass rod, tripod stand, spirit lamp/Bunsen burner, spatula, stop watch. Chart papers markers **Methodology**	

introduction: Teacher will introduce the factors which can affect the rate of reaction like concentration, temperature, surface area, catalyst.
Instructions: Teacher will give instructions about the activity to the students.
Students will be divided into 4 groups; each group will be provided with the different materials. 1 group will explore the effect of concentration, the other will explore the effect of temperature and surface area and pressure/volume respectively.
Activity:
Group 1. Will explore the **effect of concentration**

- They will take one spatula of baking soda in a beaker and will add 20 ml of concentrated vinegar (acetic acid) in it and will see the bubbles coming out of it and record the time for completion of the reaction'
- In the second step they will add 5 ml of vinegar and 15 ml of water to dilute it and repeat the above step and will record the time for their presentation and make a conclusion based on results.

Group 2. Will explore the **effect of temperature**

- They will take two full spatulas of salt in a beaker and add 20 ml of water in it to dissolve the salt in it at room temperature and record the time.
- In the second step They will take two full spatulas of salt and add them in boiling water (20 ml) and record the time taken by the salt to dissolve then they make a conclusion based on results.

Group 3. Will explore the **effect of a surface area**
This group will take granulated and powdered sugar and dissolve them separately in two different beakers half filled with water and record the time of sugar dissolution in water for both the beakers.
Make a conclusion and record it on the chart paper for presentation.
Group 4. Will explore the **effect of a catalyst**

- This group will add water in sugar and then add one or two drops of dilute sulfuric acid in it and record the changes going on in the reaction mixture.
- Sugar will quickly oxidize and change its colour.
- Dilute acid works as a catalyst in this reaction.
- Students will find out some more catalysts in different reactions.

Presentation: Students will share their understanding with the class by presenting their presentations.

Wrap up: Teacher will explain the factors affect the rates of reaction

Teacher's Notes: Teacher will have to plan this activity.

Skills: Thinking skills, communication skills.

Assessment
By the presentation of students' learning.
Rubric
Rate of reaction is directly proportional to temperature
Pressure effect on rate
Definition of catalyst
Effect of catalyst on rate of reaction

Teaching learning Evaluation:

Domain: Domain E: Organic Chemistry	
Standard: Basics of organic chemistry (catenation, isomerism, nomenclature, functional groups, homologous series) Students should be able to: Describe the concept of catenation, including the ability of carbon atoms to bond with each other to form complex structures. Explain the concept of isomerism in organic compounds, including structural and stereoisomers. Discuss the systematic nomenclature of organic compounds, including IUPAC rules.	
Student Learning Outcomes: Students will be able to name and draw the displayed formulae of the unbranched esters containing up to 4 carbon atoms Name and draw the displayed formulae of the unbranched esters which can be made from unbranched alcohols and carboxylic acids, each containing up to four carbon atoms	
Knowledge: get knowledge of catenation, Isomerism structural and stereoisomers. homologous series & IUPAC rules of nomenclature of organic compounds functional groups,	**Skills: can describe and define characteristic properties of organic compounds i.e** catenation, structural Isomerism and stereoisomers. homologous series & IUPAC rules of nomenclature of organic compounds functional groups,
Perspectives: Basics of organic chemistry (catenation, isomerism, nomenclature, functional groups, homologous series) isomerism in organic compounds, including structural and stereoisomers. systematic nomenclature of organic compounds, including IUPAC rules.	
Activity# 8 **Materials** Writing board Instruction sheet Modelling kits or playdough and toothpicks. **Methodology** **introduction:** Teacher will introduce the esters and their formula in a previous class and will continue the concept in this lesson. **Activity:** ● Teacher will display a chart paper with two different 4 carbon membered esters. ● Students will be provided with a worksheet having the same formulas and then they will make molecules by using the playdough and toothpicks or modelling kits. ● They will mark carbon atoms and write their names in the provided worksheets. **Wrap up by the students.**	

Skills: Thinking skills, communication skills.

Assessment:

1. By checking the correct names of esters on the worksheet.

Teaching learning Evaluation:

Domain: **Domain E: Organic Chemistry**

Standard: (Hydrocarbons) Students should be able to:.
Explain the reaction mechanisms and products of alkane, alkene, and alkyne reactions, including combustion, addition, and substitution reactions.

Student Learning Outcomes: Students will be able to understand the substitution reactions.
[SLO: C-09-E-13]
Describe the substitution reaction of alkanes with chlorine as a photochemical reaction, and draw the structural or displayed formulae of the products, limited to monosubstitution

Knowledge:
Students will get information about
the substitution reaction of alkanes with chlorine as a photochemical reaction, and draw the structural or displayed formulae of the products, limited to Mon substitution reaction

Skills:
Students should be able to:
Explain the reaction mechanisms and products of alkane, alkene, and alkyne reactions, including combustion, addition, and substitution reactions.

Perspectives:
the substitution reaction of alkanes with chlorine as a photochemical reaction, and draw the structural or displayed formulae of the products, limited to Mon substitution reaction

Activity#9

Materials
Writing board
Instruction sheet
Modelling kits, 5 chairs and 6 students to play musical chairs.
Methodology
introduction: Teacher will explain the substitution reactions with the help of the modelling kit and reactions.
Activity:

- Teacher will give instructions to the students.
- Students will play musical chairs
- They will see that out of 5 chairs in students will substitute the other and then they will relate it with the reactions that how one atom will substitute the other
- They will use modelling kit to explore types of substitution reactions

Wrap up by the students.

Skills: Critical thinking, communication skills.

Assessment of objectives: (specify tools of assessment)

1. By using the modelling kit to show substitution reactions.

Teaching learning Evaluation:

Domain: **Domain E: Organic Chemistry**

Standard: (Hydroxy Compounds) Students should be able to:
Discuss the applications of alcohols, including their use as solvents, fuels, and starting materials for organic synthesis.
Describe the importance of alcohols in organic chemistry and their role in industry and daily life.

Student Learning Outcomes: Students will be able to understand the application of alcohol.
Discuss the applications of alcohols as fuels, including their advantages and disadvantages over fossil fuels
Explain the role of alcohols in various industries such as pharmaceuticals, cosmetics, and fuel production.

Knowledge:

- Get knowledge of hydroxy compounds i.e alcohol
- Identify functional group -OH
- the applications of alcohols,
- use of alcohols in organic chemistry and their role in industry and daily life.

Skills:

- Identify alcohol functional group -OH
- Importance of alcohol.

Perspectives:
Alkane, alkene, alkyne
Homologous series
Concept of Saturation and unsaturation
Difference between Saturation and unsaturation
reaction mechanisms and identification of combustion, addition, and substitution reactions.

Activity# 10

Materials
Writing board
Instruction sheet.
Hand sanitizers, perfumes, medicines, spirit, alcoholic swabs, ethanol as fuel in spirit lamp, As solvents.
Worksheet.
Methodology
introduction: Teacher will introduce the types and application of alcohols
Activity:
- Teacher will display all above samples on the table and will call students in groups.
- Students will come in groups of 4 to observe the samples and the teacher will ask questions about the displayed samples.
  What does a hand sanitizer contain?
  What is the solvent for perfumes and medicines?
  Why are spirit and alcohol swabs used?
  What is used as fuel in spirit lamps?
- Teacher will give a worksheet containing the same questions and some advanced questions related to alcohol which have already been taught in the class.
- Students will answer the questions given in the worksheet.

Wrap up by the students.
Teacher notes:
Teacher will make a worksheet in which students will write their answers related to the materials provided to them.

Skills: Analytical and Communication skills

Assessment of objectives: (specify tools of assessment)
1. By checking the answers in the worksheet.

Teaching learning Evaluation:

Domain: Chemical Foundation
Topic: Fundamental Concepts in Chemistry

Standard: Students should be able to:
- Describe the nature of matter and its properties, including physical and chemical properties.
- Identify the branches of chemistry and explain the interdisciplinary relationships between chemistry and other sciences.
- Discuss the importance of chemistry in daily life and the role of chemists in society.
- Convert units and numbers in standard or scientific notation

Benchmark I: Students can explain the fundamental concepts and definitions of chemistry, including the nature of matter and its composition, elements, and compounds.

Student Learning Outcomes

Introduction to Chemistry

1. Describe chemistry as study of properties, reactions and behaviour of matter and use of those substances to create new ones.
2. Recognize that people who study chemistry are called chemists
3. Explain that chemistry has many subfields and involves interdisciplinary fields. Students should be able to recognize the following broad subfields with their examples (definitions are not required, an understanding should be developed)

- Analytical chemistry
- Biochemistry
- Inorganic chemistry
- Organic chemistry
- Neurochemistry
- Nucleur chemistry
- Physical Chemistry
- Theoretical Chemistry

Interdisciplinary fields may include agrochemistry, cosmochemistry, environmental chemistry, molecular biology, organometallic chemistry, nanotechnology and pharmacology.

4. Identify applications of sub-disciplines of chemistry such as nanochemistry, cosmochemistry in drug delivery, genetic engineering, electronics, catalysis

Units

1. Understand that units are standardised for better communication and collaboration.
2. Be familiar with SI units especially mass, time and amount of matter
3. Understand that units can be combined with terms for magnitude especially kilo, deci, and milli
4. Understand that chemists use cm^3, g and s as more practical units when working with small amounts in lab
5. Understand that errors are inherent part of measurement, and we can manage precision and accuracy with better tools and techniques

Scientific Notation/Standard Form

1. Use the standard form A × 10^n where n is a positive or negative integer, and $1 \leqslant A < 10$
2. Convert numbers into and out of standard form.
3. Calculate with values in standard form.

Knowledge:

Students will know…

- The definition of chemistry, the line of study it is related to and the interdisciplinary fields of this science.
- The conversion of numbers to scientific notation and the use of several prefixes.
- Different subfields of chemistry and their domains.

Students will understand…

- Terms like Matter, Energy, Units, and Scientific Notation.

Skills:

Students will be able to…

- Express the physical world in terms of matter and its composition.
- Distinguish between different states of matter and their involvement in daily life.
- Identify various elements of daily use and imagine their applications.

Perspectives

- Industrial Applications: Explore how different branches of chemistry, such as organic chemistry, inorganic chemistry, and physical chemistry, are applied in various industries, such as pharmaceuticals, materials science, and energy. For example, in Pakistan, the pharmaceutical industry heavily relies on organic chemistry to synthesize new drugs and the energy sector relies on inorganic chemistry to improve fuel efficiency.
- Historical Development: Trace the historical development of each branch of chemistry and how it evolved over time. For instance, physical chemistry originated in the late 19th century and was heavily influenced by the development of thermodynamics, whereas biochemistry only became a separate branch of chemistry in the early 20th century with the discovery of DNA.
- Interdisciplinary Nature: Emphasise the interdisciplinary nature of chemistry and how branches of chemistry overlap and interact with each other and with other sciences such as biology, physics, and engineering. For example, physical chemistry provides the foundation for understanding the behaviour of biological molecules, and biochemistry builds upon the principles of organic chemistry.
- The Importance of Units in Scientific Measurements: Understanding the importance of having a standardised system of units for chemical measurements is crucial for accurate communication in the scientific community. In the context of Pakistan, it's important for students to understand the use of units in industrial processes, such as the production of fertiliser, textiles, and pharmaceuticals, and the role that accurate measurements play in the quality control of these products.
- The Historical Development of Units: Throughout history, different civilizations have used different systems of units for measurements, such as the Egyptian cubit or the Roman foot. Understanding the evolution of these systems and the need for a standardised system highlights the role of science in shaping our understanding of the world and the importance of accurate measurements in scientific advancement.
- The Role of Scientific Notation in Chemical Calculations: Scientific notation is a useful tool for expressing very large or very small numbers in a concise and readable manner. In the context of chemistry, this can be used to represent the amount of a chemical substance, the concentration of a solution, or the energy of a chemical reaction. Understanding the importance of scientific notation helps students to accurately perform calculations and interpret data in chemistry experiments.

Learning Activities

1. **Exploring the Nature of Matter**

Objectives:
Describe the nature of matter and its properties, including physical and chemical properties
Identify the branches of chemistry and explain the interdisciplinary relationships between chemistry and other sciences
Discuss the importance of chemistry in daily life and the role of chemists in society
Convert units and numbers in standard or scientific notation

Materials:
Whiteboard and markers
Measuring tools such as graduated cylinders, balances, thermometers, etc.
A selection of common household items (examples: sugar, vinegar, baking soda, salt, oil, etc.)
Lab notebooks and pens
A periodic table
A reference guide for unit conversion

Introduction:
Begin the activity by having students brainstorm a list of common substances they interact with in daily life
Write their responses on the whiteboard
Ask students to categorise the substances according to their physical and chemical properties
Discuss the definitions of physical and chemical properties and give examples for each category.

Experiment:
Provide each student with a set of common household items
Ask students to perform a set of physical tests on the items, such as measuring the density, melting point, boiling point, and solubility.
Have students record their observations in their lab notebooks.

Conclusion:
Review the objectives of the activity and discuss the key takeaways.
Encourage students to continue exploring the nature of matter and the importance of chemistry in their daily lives.

Assessment:
Evaluate students based on their participation in the activity, lab notebook entries, and ability to convert units and numbers.

References:
"Chemistry: The Central Science" by Brown, LeMay, Bursten, and Burdge
"Chemistry: An Atoms First Approach" by Zumdahl and Zumdahl
"Chemistry: A Molecular Approach" by Nivaldo J. Tro
"Chemistry: Structure and Properties" by Richard H. Langley

2. **Real World Unit Conversion Challenge**

Objective: To engage higher level thinking skills by having students apply their knowledge of unit conversion to real-world problems.

Materials:
- Metric conversion chart or calculator
- Several real-world problems related to unit conversion (examples below)

Instructions:
- Divide the class into small groups of 2-3 students.
- Give each group a set of real-world problems related to unit conversion.
- Allow the students to work together to solve the problems, using their metric conversion chart or calculator as needed.
- After a set amount of time, have each group present their solutions to the class, discussing the process they used to arrive at their answers.
- Encourage class discussion and critical thinking by asking questions such as "Why did you choose that method?" or "What other methods could you have used?"

Examples of Real-World Problems:
- Convert 5 gallons of gasoline to liters.
- A car travels 50 miles on 6 gallons of gasoline. What is the car's miles per gallon (mpg) rating?
- A swimming pool holds 20,000 gallons of water. How many liters is this?
- The speed limit on a certain road is 65 miles per hour. What is this speed in kilometres per hour?
- A person has a fever of 100°F. Convert this temperature to degrees Celsius.

Assessment:
Observe the students' problem-solving process and the accuracy of their answers. Have the students write a reflection on their learning, discussing what they learned about unit conversion and their problem-solving strategies.

3. **Introduction to the Fundamentals of Chemistry**

Objective: To introduce students to the basic concepts and principles of chemistry, including atomic structure, chemical bonds, and chemical reactions.

Materials:
- Plastic containers with lids (at least 2)
- Measuring cups
- Measuring spoons
- Baking soda
- Vinegar
- Food colouring
- Balloon
- String
- Masking tape

Procedure:

- Fill one of the plastic containers with a mixture of 1/2 cup of baking soda and 1/4 cup of water.
- Add a few drops of food colouring to the mixture and stir until it is well mixed.
- Fill the second container with a mixture of 1/2 cup of vinegar and 1/4 cup of water.
- Stretch a balloon over the opening of the container with the baking soda mixture and secure it in place using a string and masking tape.
- Slowly pour the vinegar mixture into the container with the baking soda mixture, taking care to observe the balloon.
- Discuss the observations with students and ask them to explain what is happening.
- Introduce the concepts of chemical reactions and atomic structure, explaining that the reaction between the baking soda and vinegar is a classic example of a chemical reaction.
- Explain that chemical reactions involve the rearrangement of atoms to form new compounds, and that this reaction results in the release of carbon dioxide gas, which is observed as the balloon expands.

Explanation:

This activity is a simple and engaging way to introduce students to the fundamental concepts of chemistry, including chemical reactions, atomic structure, and chemical bonds. By observing the reaction between baking soda and vinegar, students can see first-hand how chemical reactions can result in the release of gases, changes in temperature, and the formation of new substances. This activity is also an effective way to introduce students to the importance of conducting experiments and making observations, which are essential skills in the study of chemistry.

Reference:

Zumdahl, S. S., & Zumdahl, S. A. (2017). Chemical principles. Cengage Learning.

Domain: Organic Chemistry
Topic: Basics of organic chemistry

Standard: Students should be able to:

1. Describe the concept of catenation, including the ability of carbon atoms to bond with each other to form complex structures.
2. Explain the concept of isomerism in organic compounds, including structural and stereoisomers.
3. Discuss the systematic nomenclature of organic compounds, including IUPAC rules.
4. Describe the functional groups in organic compounds, including alcohols, carboxylic acids, amines, and aldehydes.
5. Explain the concept of homologous series, including the similarity in properties and reactivity among members of a series.

Benchmark 1: Recognize and classify organic compounds based on their functional groups, nomenclature, isomerism, and homologous series.

Student Learning Outcomes

Formulae, functional groups and terminology

1. State that a structural formula is an unambiguous description of the way the atoms in a molecule are arranged, including $CH_2{=}CH_2$, CH_3CH_2OH, CH_3COOCH_3
2. Draw and interpret the displayed formula of a molecule to show all the atoms and all the bonds
3. Write and interpret general formulae of compounds in the same homologous series, limited to:

   (a) alkanes

   (b) alkenes

   (c) alcohols

   (d) carboxylic acids
4. Define structural isomers as compounds with the same molecular formula, but different structural formulae, including C_4H_{10} as $CH_3CH_2CH_2CH_3$ and $CH_3CH(CH_3)CH_3$ and C_4H_8 as $CH_3CH_2CH{=}CH_2$ and $CH_3CH{=}CHCH_3$
5. Identify a functional group as an atom or group of atoms that determine the chemical properties of a homologous series including that for alcohols, aldehydes, ketones, phenols, carbxylic acids, amine, esters, and amide.
6. Describe the general characteristics of a homologous series as:

   (a) having the same functional group

   (b) having the same general formula

   (c) differing from one member to the next by a $–CH_2–$ unit

   (d) displaying a trend in physical properties

   (e) sharing similar chemical properties
7. State that a saturated compound has molecules in which all carbon–carbon bonds are single bonds
8. State that an unsaturated compound has molecules in which one or more carbon–carbon bonds are not single bonds
9. Explain why a systematic method of naming chemical compounds is necessary.

Naming organic compounds

1. Name and draw the structural and displayed formulae of unbranched:

   (a) alkanes

   (b) alkenes, including but-1-ene and but-2-ene

   (c) alcohols, including propan-1-ol, propan-2-ol, butan-1-ol and butan-2-ol

(d) carboxylic acids

(e) the products of the reactions stated in next sections containing up to four carbon atoms per molecule

2. State the type of compound present given the chemical name ending in -ane, -ene, -ol, or -oic acid or from a molecular, structural or displayed formula
3. Name and draw the displayed formulae of the unbranched esters which can be made from unbranched alcohols and carboxylic acids, each containing up to four carbon atoms

Knowledge:
Students will know…
- The formulae and functional groups of different organic compounds.
- Nomenclature of commonly used organic compounds like alkanes, alkenes, alcohols, and carboxylic acids.
- The common characteristics of a homologous series.
- The distinction between saturated and unsaturated compounds and the process of interconversion.

Students will understand…
- Terms like homologous and saturated compounds, catenation, isomerism, and functional groups.

Skills:
Students will be able to…
- Identify the organic compounds commonly used in cooking, agriculture, labs, and industries.
- Distinguish between various groups of organic compounds and explain their general characteristics.
- Explain the catenation of organic compounds and the change in properties with the addition of my CH2 units.

Perspectives
- The impact of early discoveries and experiments in organic chemistry on modern medicine and drug development, including the isolation and synthesis of important natural products like aspirin, quinine, and penicillin.
- The role of organic chemistry in the development of industrial processes and products, including the synthesis of synthetic materials, such as plastics and fibres, and the production of fuels, such as gasoline and diesel.
- The environmental impact of organic chemistry and the role of organic chemists in developing sustainable and environmentally friendly alternatives to traditional processes and products.
- Impact of colonialism on organic chemistry nomenclature: Colonialism played a significant role in shaping the way organic compounds were classified and named, as European colonizers brought back new knowledge and samples from their colonies and introduced new naming systems and taxonomies to the Western world. This had a lasting impact on the field of organic chemistry, and in some cases, has perpetuated Eurocentric biases and hierarchies in the classification of organic compounds.

Learning Activities

1. **Introduction to Organic Nomenclature**

Objective: To introduce students to the basic principles and conventions of organic nomenclature.

Materials:

- Structural formulas of different organic compounds
- Molecular models or ball-and-stick models of different organic compounds
- Nomenclature worksheets
- Pencils
- Erasers

Introduction:
In organic chemistry, it is important to be able to name compounds in a standardised way. This allows for clear communication among chemists and helps to avoid confusion. In this activity, students will learn the basic rules and conventions used in naming organic compounds.

***Procedure*:**
Divide students into small groups of 2-3 students each.
Provide each group with a set of structural formulas of different organic compounds.
Instruct students to use their knowledge of organic structure and functional groups to name each compound according to IUPAC (International Union of Pure and Applied Chemistry) nomenclature rules.
Once students have completed the worksheet, have them check their answers with their group members.
As a class, review any incorrect answers and discuss the reasoning behind the correct nomenclature.
Use molecular models or ball-and-stick models to demonstrate the relationships between the structural formula and the nomenclature of each organic compound.
Assign additional practice problems for students to complete on their own or in groups.
Assessment:
Students will be assessed on their ability to correctly name organic compounds using IUPAC nomenclature. This can be done through the completion of a written test or through a practical demonstration, such as modelling the structure of a given compound and providing its correct name.

***References*:**
Clayden, J., Greeves, N., Warren, S., & Wothers, P. (2012). Organic chemistry (2nd ed.). Oxford, UK: Oxford University Press.
Carey, F. A., & Sundberg, R. J. (2007). Advanced organic chemistry: Part A: Structure and mechanisms (5th ed.). New York, NY: Springer.
McMurry, J. (2008). Organic chemistry (7th ed.). Boston, MA: Brooks/Cole.

2. **Organic Molecules: What's in Your Food?"**

Objective: Students will learn about the different types of organic molecules (carbohydrates, lipids, proteins, and nucleic acids) and identify them in common food items.

***Materials*:**
- A variety of food items (e.g. fruits, vegetables, snacks, etc.)

- Small cups or containers
- Filter paper or coffee filters
- Glucose test strips
- Benedict's solution
- Biuret reagent
- Sudan III/IV solution
- Toothpicks or droppers

***Procedure*:**
Divide students into small groups.
Give each group a different food item to test.
Have students use the filter paper or coffee filters to extract the organic molecules from their food item.
To test for carbohydrates, use the glucose test strips or Benedict's solution. To test for lipids, use Sudan III/IV solution. To test for proteins, use Biuret reagent.
Have students observe and record the results of their tests.
Have students discuss their results and identify which type of organic molecule is present in their food item.
Finally, have students present their results to the class and discuss the importance of each type of organic molecule in our diet.

***References*:**
Brown, T.L., LeMay, H.E., Bursten, B.E., and Burdge, J.J. (2017). Chemistry: The Central Science, 14th Edition. Pearson Education Inc.
"Organic Molecules Lab" by Science With Mrs. Lau, https://sciencewithmrslau.com/organic-molecules-lab/

Domain: Biochemistry

Standard: Students should be able to:
- Describe the structure and properties of carbohydrates, proteins, and lipids, including their classification as monosaccharides, disaccharides, polysaccharides, amino acids, peptides, and fatty acids.
- Explain the metabolic pathways and functions of carbohydrates, proteins, and lipids in living organisms, including energy storage and transfer, structural support, and regulatory roles.
- Describe the structure and function of DNA and RNA, including the role of DNA in genetics and the mechanism of transcription and translation.
- Discuss the importance of vitamins and minerals in human nutrition, including their role in metabolic processes and the consequences of deficiencies.
- Apply the concepts of biochemistry to understand the molecular basis of biological processes, diseases, and treatments.

Benchmark I: Identify and draw the structure and function of carbohydrates, proteins, fats, DNA and vitamins in biological systems.

Student Learning Outcomes

1. Describe proteins as natural polyamides and that they are formed from amino acid monomers with the general structure
2. Describe and draw the structure of proteins
3. Explain the sources, use and structure of proteins, lipids and carbohydrates
4. Describe the importance of nucleic acids
5. Describe and explain vitamins, their sources and their importance to health
6. Identify applications of biochemistry in testing (blood test, pregnancy test, cancer screening, parental genetic testing), genetic engineering, gene therapy and cloning

Knowledge:

Students will know…

- The differences between the four major biomolecules.
- The sources and use of different biomolecules in the body.
- The applications of biology in healthcare and industries.

Students will understand…

- Terms like Nucleic Acids, Lipids, Vitamins, Carbohydrates, and Proteins.

Skills:

Students will be able to…

- Describe the structures of different biomolecules and their composition.
- Identify the different sources of food that these biomolecules are obtained from.
- Explain how different biomolecules are stored inside our bodies and how energy is extracted from them.

Perspectives

- Biochemistry is the study of the chemical processes that occur within living organisms, and it is a fundamental part of understanding how living things work.
- The structure and properties of carbohydrates, proteins, and lipids play a critical role in the functions and metabolic processes of living organisms.
- Understanding the role of DNA and RNA in genetics and cellular processes is crucial for comprehending how living organisms function and evolve.
- Vitamins and minerals play a vital role in maintaining health and wellbeing, and their deficiencies can have significant impacts on human biology.
- The application of biochemistry has significant implications for medicine and biotechnology, providing insights into disease processes and enabling the development of new treatments.

Learning Activities

1. **Exploring the Properties of Proteins**

Objective: To understand the properties of proteins and how they can be affected by changes in temperature, pH, and other conditions.

Materials:

- 4 test tubes
- 4 mL of egg white (or another protein solution)

- 4 mL of distilled water
- 1 mL of 1 M HCl
- 1 mL of 1 M NaOH
- Bunsen burner or hot plate
- Test tube holder
- Graduated cylinder

Procedure:

- Label four test tubes as T1, T2, T3, and T4.
- Fill T1 with 4 mL of egg white.
- Fill T2 with 4 mL of distilled water.
- Fill T3 with 4 mL of egg white and 1 mL of 1 M HCl.
- Fill T4 with 4 mL of egg white and 1 mL of 1 M NaOH.
- Use a Bunsen burner or hot plate to gently heat T1 until it reaches 70-80°C. Keep T2, T3, and T4 at room temperature.
- Observe and record any changes in the appearance of the solutions in each test tube.
- Compare the results of each test tube to the original solution in T1.

Sample Results:

- T1 (original egg white solution): A clear, viscous solution with a slightly opaque appearance.
- T2 (distilled water): A clear, colorless solution with no change in appearance.
- T3 (egg white + HCl): The solution may become cloudy or form a precipitate, indicating that the protein has denatured due to the change in pH caused by the addition of HCl.
- T4 (egg white + NaOH): The solution may become clearer or less viscous, indicating that the protein has denatured due to the change in pH caused by the addition of NaOH.

This activity helps students understand the properties of proteins and how they can be affected by changes in temperature, pH, and other conditions. By observing and recording the changes in the appearance of the solutions, students are able to understand the concept of denaturation and the role of pH in protein structure and function.

2. **Lipid Extraction and Analysis**

Objectives:

To extract lipids from a food source and identify their chemical structure

To understand the role of lipids in biological systems

Materials:

- Vegetable oil
- Ethanol
- Sodium hydroxide
- Beaker
- Test tubes
- Hot plate or Bunsen burner
- Dropper
- TLC (Thin Layer Chromatography) plate
- Solvent (such as hexane and ether)
- Ruler
- Pencil
- Spot plate

Procedure:

- Place about 10 mL of vegetable oil in a test tube and add 1 mL of sodium hydroxide solution. Shake the test tube to mix the two liquids.
- Slowly add ethanol to the test tube while swirling the mixture. You will notice a solid material precipitating out of the solution. This is the lipid that you will extract.

- Filter the mixture using a filter paper or funnel. Collect the solid material in a spot plate.
- Using a TLC plate, spot a small amount of the extracted lipid and a known lipid (such as olive oil) onto the plate.
- Develop the TLC plate by placing it in a solvent system (such as hexane and ether). As the solvent moves up the plate, the lipids will separate and migrate up the plate.
- Observe the position of the spots on the TLC plate and measure the distance each spot has traveled. This will give you an idea of the chemical structure of the lipids.
- Compare the distance travelled by the unknown lipid with the known lipid. Based on the distance travelled, you can make an educated guess as to the type of lipid extracted from the vegetable oil.
- Repeat the procedure using different food sources and compare the results.
- Discuss the role of lipids in biological systems, such as the role of fats in energy storage and membrane structure.

References:

"Lipid Analysis - Thin Layer Chromatography." ScienceDirect Topics, Elsevier, www.sciencedirect.com/topics/chemistry/lipid-analysis-thin-layer-chromatography.

"Thin Layer Chromatography of Lipids." Bitesize Bio, bitesizebio.com/11673/thin-layer-chromatography-of-lipids/.

This activity provides hands-on experience in lipid extraction and analysis, and helps students understand the role of lipids in biological systems. In schools where TLC plates may not be available, teachers can use an activity to make nylon instead.

(Note: If Nylon is not available, use cellulose filters instead of nylon, as an alternative.)

3. **Demonstrating the Insulating Properties of Lipids Using Metal Rods**

Objective**:** To demonstrate how lipids function as thermal insulators by measuring the temperature change of metal rods covered in lipid substances.

***Materials*:**

- 2 metal rods with the same diameter
- Cooking oil
- Shortening or margarine
- Water
- Thermometer
- Beaker
- Heat source (e.g. hot plate or stove)

Procedure:

- Measure the initial temperature of both metal rods using the thermometer. Record the temperature and plot the graph in your lab notebook.
- Place one metal rod into a beaker filled with water and heat the beaker using a heat source until the temperature of the water reaches 50°C.
- Quickly remove the metal rod from the hot water and measure its temperature again using the thermometer. Record the temperature in your lab notebook.
- Repeat steps 2 and 3 with the second metal rod, but this time, cover the rod with a thin layer of cooking oil or shortening/margarine before heating it in the beaker of hot water.
- Measure the temperature of the second metal rod after heating and record the temperature in your lab notebook.

Data Analysis:

- Calculate the temperature change for both metal rods by subtracting the initial temperature from the final temperature.
- Compare the temperature change of the two metal rods.

Expected Results:

The metal rod covered in lipid substances (cooking oil or shortening/margarine) should experience a smaller temperature change compared to the metal rod without any lipid covering.
This demonstrates that lipids are effective thermal insulators, as they slow down the transfer of heat from the metal rod to the surrounding water.

Conclusion:
The experiment shows how lipids function as thermal insulators, which is important for maintaining the temperature stability of living organisms. Lipids play a crucial role in protecting the body from extreme temperature changes and maintaining the internal temperature of cells and tissues.

GRADE 11-12

Domain: **Domain B: Physical Chemistry**

Standard:
Describe the arrangement of electrons in the electron shells and explain how this arrangement affects the chemical properties of an atom.

Student Learning Outcomes: By the end of this activity, students will understand the significance of electronic configuration in the development of new materials.
Illustrate the importance of electronic configurations in development of new materials for electronic devices.
(For example, semiconductors such as silicon have a specific electronic configuration that makes them ideal for use in electronic devices.)

Knowledge: students will understand the electronic configuration of elements Describe the arrangement of electrons in the electron shells explain how electronic configuration helps to determine the chemical properties of an atom.	**Skills: Students will be able** **To do electronic configuration** **To relate the electronic configuration and chemical properties**

Perspectives:
Atomic number and arrangement of electrons
understand the electronic configuration of elements
Describe the arrangement of electrons in the electron shells
explain how electronic configuration helps to determine the chemical properties of an atom

Activity # 1

Materials needed:

- Whiteboard or blackboard
- Markers or chalk
- Chart paper
- Colored pencils or markers
- Handouts with examples of materials and their electronic configurations (optional)

Procedure:

Stage	Activity

Introduction The teacher begins the lesson by introducing the topic of electronic configuration and its importance in the development of new materials. The teacher explains that the electronic configuration of atoms determines their chemical properties and how they interact to form different materials.
Discussion and Examples The teacher initiates a class discussion on the concept of electronic configuration and its relationship to the properties of materials. The teacher provides examples of materials and their electronic configurations, such as conductors, insulators, and semiconductors. Students are encouraged to participate actively in the discussion, ask questions, and share their observations.
Group Activity: Building Molecular Models Divide the students into small groups of 3-4 members. Provide each group with a set of molecular model kits or other materials for building models (e.g., colored beads, pipe cleaners). Assign each group a specific material to create a model for (e.g., diamond, graphene, silicon). Instruct the groups to build the molecular models of their assigned materials, considering the electronic configuration of the atoms involved. Encourage students to discuss and analyze how the electronic configuration affects the properties of the material they are modeling. The teacher moves around the classroom, providing guidance, answering questions, and facilitating discussions among the groups.
Group Presentation and Discussion Each group presents their model to the class, explaining the electronic configuration and discussing the properties of the material they created. The teacher facilitates a class discussion by asking questions related to the electronic configuration, properties, and potential applications of the materials presented. Students are encouraged to ask questions and provide feedback to their peers.
Conclusion and Wrap-up The teacher summarizes the key points discussed during the activity, emphasizing the importance of electronic configuration in the development of new materials. The teacher provides additional resources or references for further exploration of the topic.

Note for teachers:

- ✔ Prior to the lesson, familiarize yourself with different materials and their electronic configurations to facilitate the discussion and answer students' questions effectively.

- ✔ Ensure that the molecular model kits or alternative materials for building models are readily available and in good condition.
- ✔ Encourage active participation and collaboration among students during the group activity.
- ✔ Time management is crucial, so ensure that each section of the activity stays within the allocated time frame.

Note for students:

- ✔ Actively engage in the class discussion and ask questions to enhance your understanding.
- ✔ Collaborate effectively with your group members during the molecular model building activity.
- ✔ Pay attention to the properties of the materials discussed and connect them to the electronic configuration.
- ✔ Participate in the group presentations and class discussions by sharing your insights and asking relevant questions.

<table>
<tr><td colspan="2">Domain: Domain B: Physical Chemistry</td></tr>
<tr><td colspan="2">Standard:
Describe the arrangement of electrons in the electron shells and explain how this arrangement affects the chemical properties of an atom.</td></tr>
<tr><td colspan="2">Student Learning Outcomes: Understand the concept of quantum numbers and their relation to the electronic distribution of atoms.
Relate Quantum Numbers to Electronic distribution of elements
Describe the number of orbitals making up s, p d and f sub-shells, and the number of electrons that can fill s, p d and f sub-shells</td></tr>
<tr><td>Knowledge: student will get knowledge
● Of quantum numbers
● Of Assignment of quantum numbers</td><td>Skills:
Students will be able to
● Identify quantum numbers
● Relate quantum numbers and properties of electrons
● Describe the number of orbitals making up s, p d and f sub-shells</td></tr>
<tr><td colspan="2">Perspectives:
Concept of quantum number
Identify quantum numbers
Relate quantum numbers and properties of electrons
Describe the number of orbitals making up s, p d and f sub-shells</td></tr>
</table>

Activity # 2
Materials Needed:

- Whiteboard or blackboard
- Markers or chalk
- Chart paper or poster board
- Colored pens or markers
- Handouts with practice problems (optional)

Stage	Activity
Introduction	Begin the lesson by discussing the concept of quantum numbers and their significance in understanding the electronic distribution of atoms.
	Emphasize the importance of quantum numbers in describing the location, energy levels, and orientation of electrons in an atom.
Discussion and Examples	Present a detailed explanation of the four quantum numbers: principal quantum number (n), azimuthal quantum number (l), magnetic quantum number (m), and spin quantum number (s).
	Use the whiteboard or blackboard to illustrate each quantum number and its role in determining the electronic distribution.
	Provide examples of electron configurations for different elements, explaining how quantum numbers are applied to determine the distribution of electrons in different energy levels and orbitals.
Group Activity: Quantum Number Charts	Divide the students into small groups of 3-4 members.
	Distribute chart paper or poster boards and colored pens or markers to each group.
	Instruct the students to create a large chart representing the quantum numbers and their possible values.
	Each group should draw columns for the four quantum numbers (n, l, m, s) and rows representing the corresponding values.
	Guide the students in filling out the chart by discussing the valid ranges of each quantum number and their significance in electronic distribution.
	Encourage the groups to collaborate and discuss the patterns and relationships between the quantum numbers.

Group Presentation and Discussion	Have each group present their quantum number chart to the class.
	Facilitate a class discussion on how the quantum numbers relate to the electron distribution and the principles of Pauli exclusion and Aufbau principle.
	Students are encouraged to ask questions and provide feedback to their peers.
Conclusion and Wrap-up	Provide handouts with practice problems related to electron configurations and quantum numbers.
	Instruct students to work individually or in pairs to solve the problems, applying their understanding of quantum numbers.

Note for teachers:

- ✔ Ensure a clear explanation of each quantum number, highlighting its definition and significance.
- ✔ Use visual aids, such as diagrams or models, to enhance students' understanding.
- ✔ Encourage active participation and collaboration among students during the interactive activity and group discussions.
- ✔ Monitor the groups during the activity to provide guidance and address any misconceptions.
- ✔ Provide additional resources, such as online simulations or interactive tutorials, for students to further explore quantum numbers and electronic distribution.

Note for students:

- ✔ Actively participate in class discussions and ask questions to clarify any doubts.
- ✔ Collaborate effectively with your peers during the group activity and take turns in presenting the quantum number charts.
- ✔ Engage in problem-solving during the practice session to reinforce your understanding of quantum numbers and electron distribution.

Domain: Domain B: Physical Chemistry
Standard: (Chemical Bonding) Students should be able to:

Explain the concept of chemical bonding and describe the different types of bonds, including ionic, covalent, and metallic bonds. Discuss the factors that affect bond strength, including bond length and bond energy.
Student Learning Outcomes: Understand the concept of electronegativity and its role in predicting bond formation between atoms. Use the differences in Pauling electronegativity values to predict the formation of ionic and covalent bonds Explain the trends in electronegativity across a period and down a group of the Periodic Table Explain the factors influencing the electronegativities of elements in terms of nuclear charge, atomic radius, shielding by inner shells and subshells

Knowledge: students will get information about	Skills: students will able to tell
• **chemical bonding** • **types of bonds (ionic, covalent, and metallic bonds).** • **Periodicity in electronegativity** • **& its values to predict the formation of ionic and covalent bonds** • **the factors (nuclear charge, atomic radius, shielding effect) influencing the electronegativities of elements**	• **why atoms form bond** • **types of bonds (ionic, covalent, and metallic bonds).** • **About electronegativity and type of bonding** • **The factors influencing the electronegativities**

Perspectives:

Activity # 3
Materials Needed:

- Whiteboard or blackboard
- Markers or chalk
- Periodic table (physical or digital)
- Chart paper or poster board
- Colored pens or markers
- Handouts with practice problems (optional)

Procedure

Stage	Activity
Introduction	Begin the lesson by introducing the concept of electronegativity and its significance in bond formation. Explain that electronegativity is a measure of an atom's ability to attract electrons in a chemical bond. Emphasise that differences in electronegativity values between atoms determine the type of bond that forms (ionic, covalent, or polar covalent).
Discussion on Electronegativity	Present a detailed explanation of electronegativity values and how they are determined. Use the periodic table to demonstrate trends in electronegativity across periods and down groups. Discuss how electronegativity varies among elements and how it affects their chemical behaviour.
Electronegativity and Bond Types	Provide examples of different elements and their electronegativity values. Explain how the difference in electronegativity values between two atoms can predict the type of bond that will form between them. - Large electronegativity difference (ΔEN) indicates an ionic bond. - Small electronegativity difference (ΔEN) indicates a covalent bond. - Moderate electronegativity difference (ΔEN) indicates a polar covalent bond.
Practice Problems	Provide handouts with practice problems related to predicting bond types based on electronegativity values. Instruct students to work individually or in pairs to solve the problems. Encourage students to use the periodic table and their understanding of electronegativity to determine bond types in each case.
Group Discussion	Facilitate a class discussion on the practice problems, allowing students to share their answers and explanations. Clarify any misconceptions and reinforce the concept of electronegativity and bond prediction. Encourage students to ask questions and engage in critical thinking.
Conclusion and Wrap-up	Summarize the key points about electronegativity and its role in predicting bond formation. Highlight the importance of electronegativity in understanding the nature of chemical bonds. Encourage students to continue exploring electronegativity and its applications in future topics.

Note for teachers:

- Ensure a clear explanation of electronegativity and its relation to bond formation.
- Use visual aids, such as the periodic table, to enhance students' understanding.
- Monitor students' progress during practice problems and provide guidance as needed.
- Encourage active participation and discussion to foster a deeper understanding of the concept.

Note for students:

- Actively participate in class discussions and ask questions to clarify any doubts.
- Work collaboratively during practice problems to reinforce your understanding of electronegativity and bond prediction.
- Review the periodic table regularly to familiarize yourself with electronegativity trends.

Domain: Domain B: Physical Chemistry

Standard:
Describe the laws of thermodynamics and their application in chemical systems.
Discuss the relationship between energy and work, and apply this relationship to thermodynamic processes.

Student Learning Outcomes: Understand the concept of Gibbs Free Energy and its role in predicting spontaneity and equilibrium in chemical reactions.
Explain Gibbs free energy

Apply the concept of Gibbs free energy to solve problems

Explain the relationship between Gibbs free energy change, ΔG, and the feasibility of a reaction

Knowledge:	Skills:
Student will **Understand** ● **the thermodynamic terms Gibbs Free Energy** ● **role of Gibbs free energy in predicting spontaneity, equilibrium in chemical reactions and the feasibility of a reaction**	**Student will able to** • **define Gibbs Free Energy** • **predict spontaneity, equilibrium in chemical reactions**

Perspectives:
the thermodynamic terms Gibbs Free Energy
role of Gibbs free energy in predicting spontaneity, equilibrium in chemical reactions and the feasibility of a reaction

Activity # 4
Materials Needed:

1. Whiteboard or blackboard

2. Markers or chalk
3. Periodic table (physical or digital)
4. Chart paper or poster board
5. Colored pens or markers
6. Handouts with practice problems
7. Calculators (optional but recommended for some calculations)

Stage 1 - Introduction

- Begin the lesson by introducing the concept of Gibbs Free Energy (G) and its significance in chemical reactions.
- Explain that Gibbs Free Energy is a thermodynamic function that indicates whether a chemical reaction is spontaneous or non-spontaneous under specific conditions.
- Emphasize that Gibbs Free Energy is related to enthalpy (ΔH) and entropy (ΔS) through the equation: $\Delta G = \Delta H - T\Delta S$, where T is the temperature in Kelvin.
- Discuss the concept of spontaneity and how it is related to Gibbs Free Energy. A negative ΔG indicates a spontaneous reaction, while a positive ΔG indicates a non-spontaneous reaction.

Stage 2 - Gibbs Free Energy and Spontaneity

- Present a detailed explanation of how to determine the spontaneity of a reaction using Gibbs Free Energy.
- Use the equation $\Delta G = \Delta H - T\Delta S$ to calculate ΔG values for various chemical reactions at different temperatures.
- Demonstrate how to interpret the sign of ΔG to predict whether a reaction is spontaneous or not.

Stage 3 - Gibbs Free Energy and Equilibrium

- Explain the relationship between Gibbs Free Energy and chemical equilibrium.
- Discuss the conditions for equilibrium, where $\Delta G = 0$.

- Illustrate how changes in temperature and reaction conditions affect the position of the equilibrium using the Gibbs-Helmholtz equation: $\Delta G = \Delta H - T\Delta S = -RT \ln(K)$, where R is the gas constant and K is the equilibrium constant.

Stage 4 - Practice Problems (Duration: 20 min)

- Provide handouts with practice problems related to calculating Gibbs Free Energy, determining spontaneity, and predicting equilibrium positions.
- Instruct students to work individually or in pairs to solve the problems.
- Encourage students to use the provided equations and periodic table as needed to perform the calculations.

Stage 5 - Group Discussion

- Facilitate a class discussion on the practice problems, allowing students to share their answers and explanations.
- Clarify any misconceptions and reinforce the concept of Gibbs Free Energy and its applications in predicting spontaneity and equilibrium.
- Encourage students to ask questions and engage in critical thinking.

Stage 6 - Conclusion and Wrap-up

- Summarize the key points about Gibbs Free Energy and its role in predicting spontaneity and equilibrium in chemical reactions.
- Highlight the importance of understanding Gibbs Free Energy for making predictions about the feasibility of reactions.
- Encourage students to continue exploring thermodynamics and its applications in future topics.

Note for Teachers:

- Ensure a clear explanation of Gibbs Free Energy and its relation to spontaneity and equilibrium.
- Use visual aids and examples to enhance students' understanding of the concept.
- Monitor students' progress during practice problems and provide guidance as needed.

- Encourage active participation and discussion to foster a deeper understanding of Gibbs Free Energy.

Note for Students:

- Actively participate in class discussions and ask questions to clarify any doubts.
- Work collaboratively during practice problems to reinforce your understanding of Gibbs Free Energy and its applications.
- Review the provided equations and concepts regularly to solidify your grasp on the topic.

<table>
<tr><td colspan="2">Domain: Domain B: Physical Chemistry</td></tr>
<tr><td colspan="2">Standard: (Reaction Kinetics) Students should be able to: Describe the nature of chemical reactions, including the activation energy and rate of reaction.</td></tr>
<tr><td colspan="2">Student Learning Outcomes: Understand the concept of Boltzmann Distribution Constant and its significance in statistical mechanics.
Use the Boltzmann distribution curve to explain the effect of temperature on the rate of a reaction</td></tr>
<tr><td>Knowledge:
Students will Understand
the concept of Boltzmann Distribution Constant and its significance in statistical mechanics.
Use the Boltzmann distribution curve to explain the effect of temperature on the rate of a reaction</td><td>Skills:
Students will be able to
Describe the Boltzmann Distribution and its Constant

Use the Boltzmann distribution curve to explain the effect of temperature on the rate of a reaction</td></tr>
<tr><td colspan="2">Perspectives:
the concept of Boltzmann Distribution Constant and its significance in statistical mechanics.
Use the Boltzmann distribution curve to explain the effect of temperature on the rate of a reaction</td></tr>
<tr><td colspan="2">Activity # 5
Materials Needed:

1. Whiteboard or blackboard</td></tr>
</table>

2. Markers or chalk
3. Handouts with practice problems
4. Calculators (optional but recommended for some calculations)

Stage 1 - Introduction

- Begin the class activity by introducing the concept of the Boltzmann Distribution Constant (k) and its role in statistical mechanics.
- Explain that k is a fundamental constant that relates temperature and energy in statistical distributions of particles.
- Emphasize that the Boltzmann Distribution describes how particles are distributed among different energy levels in a system at a given temperature.

Stage 2 - Basic Concept and Equation

- Present a detailed explanation of the Boltzmann Distribution equation: $P(E) = (1/Z) * e^{(-E/kT)}$, where $P(E)$ is the probability of a particle being in an energy state E, T is the absolute temperature, k is the Boltzmann constant, and Z is the partition function.
- Discuss the significance of the partition function in calculating probabilities of different energy states.

Stage 3 - Interactive Simulation

- Conduct an interactive simulation using the students as "particles" to demonstrate the Boltzmann Distribution.
- Divide the students into different energy states, with each group representing an energy level.
- Have a "temperature moderator" (teacher or student) randomly move the students between energy levels to simulate the distribution of particles at a given temperature.
- Discuss how the distribution changes with temperature and how the Boltzmann Distribution Constant influences the probability of particles being in different states.

Stage 4 - Practice Problems

- Provide handouts with practice problems related to the Boltzmann Distribution and the calculation of probabilities for different energy states.

- Instruct students to work individually or in pairs to solve the problems.
- Encourage students to use the Boltzmann Distribution equation and apply their understanding of the concept.

Stage 5 - Group Discussion and Conclusion

- Facilitate a class discussion on the simulation and practice problems, allowing students to share their answers and explanations.
- Clarify any misconceptions and reinforce the concept of the Boltzmann Distribution Constant and its significance in statistical mechanics.
- Summarize the key points about the Boltzmann Distribution and its role in describing the distribution of particles in different energy states at a given temperature.

Note for Teachers:

- Ensure active participation of students during the interactive simulation.
- Use visual aids and examples to enhance students' understanding of the concept.
- Encourage student interactions and discussions to foster a deeper understanding of the Boltzmann Distribution Constant.

Note for Students:

- Actively participate in the interactive simulation and group discussions.
- Work collaboratively during practice problems to reinforce your understanding of the Boltzmann Distribution Constant.
- Review the concepts regularly to solidify your grasp on the topic of statistical mechanics.

Domain: **Domain B: Physical Chemistry**
Standard:. Discuss the principles of isotopes, including atomic mass and isotopic abundance.
Student Learning Outcomes: Enable students to deduce the molecular mass of a compound from a given mass spectrum through collaborative analysis and critical thinking. Explain how a mass spectrometer can be used to determine the relative atomic mass of an element from its isotopic composition

Knowledge:
Students will understand
- **The experimental determination of molecular mass of a compound from a given mass spectrum**
- **how a mass spectrometer can be used to determine the relative atomic mass of an element from its isotopic composition**

Skills:
Students will be able to
- **Describe mass spectrum**
- **Determine molecular mass of a compound**
- **determine the relative atomic mass of an element from its isotopic composition with the help of a mass spectrometer**

Perspectives
Isotopes, including atomic mass and isotopic abundance.
Describe mass spectrum
Determine molecular mass of a compound
determine the relative atomic mass of an element from its isotopic composition with the help of a mass spectrometer
The experimental determination of molecular mass of a compound from a given mass spectrum
how a mass spectrometer can be used to determine the relative atomic mass of an element from its isotopic composition

Activity# 6
Materials Needed:

1. Whiteboard or blackboard
2. Projector or screen (optional, for displaying mass spectrum)
3. Mass spectrometry data of a compound (provided in handouts or projected on the screen)

Stage 1 - Introduction

- Begin the activity by briefly introducing the concept of mass spectrometry and its application in determining the molecular mass of compounds.
- Explain that a mass spectrum is a plot of the intensity of ions against their mass-to-charge ratio (m/z).
- Emphasize that students will work together to deduce the molecular mass of a compound based on the given mass spectrum.

Stage 2 - Analyzing the Mass Spectrum

- Divide the students into small groups (3-4 students per group).
- Provide each group with a mass spectrum of a compound (either in handouts or displayed on the screen).
- Instruct the groups to analyze the mass spectrum collaboratively.
- Guide students to identify the molecular ion peak, fragment peaks, and other relevant peaks in the spectrum.
- Encourage students to discuss and interpret the peak patterns and intensities.

Stage 3 - Deduction and Calculation

- Ask each group to deduce the molecular mass of the compound based on the mass spectrum analysis.
- Remind students to consider the mass of the molecular ion and any fragment ions present in the spectrum.
- Assist the groups as needed and encourage them to use critical thinking and problem-solving skills.
- Once each group has calculated the molecular mass, have them share their findings with the class.

Stage 4 - Group Presentations and Discussion

- Ask each group to present their deduction process and the calculated molecular mass to the class.
- Encourage other students to ask questions and engage in discussions about the analysis and results.
- Facilitate a class discussion to compare the results from different groups and ensure a clear understanding of the concept.

Note for Teachers:

- Provide support and guidance to students as they analyze the mass spectrum and deduce the molecular mass.

- Encourage active student participation and discussions to foster a student-centered learning environment.
- Use the opportunity to clarify any misconceptions and reinforce the concepts related to mass spectrometry and molecular mass determination.

Note for Students:

- Collaborate and actively participate in the group analysis of the mass spectrum.
- Use critical thinking skills to deduce the molecular mass of the compound based on the given data.
- Be prepared to present your findings to the class and engage in discussions with other students.

Domain: Domain B: Physical Chemistry	
Standard: Apply the principles of chemical bonding to explain the physical properties of materials.	
Student Learning Outcomes: Enable students to understand the significance of the VSEPR theory (Valence Shell Electron Pair Repulsion theory) in drug design through collaborative exploration and group discussions. *Explain the importance of VSEPR theory in the field of drug design by discussing how the shape and bond angles of the molecules helps chemists predict their interactions in the body.*	
Knowledge: students will understand ● **VSEPR theory** ● **Shape of molecules** ● ***the importance of VSEPR theory in the field of drug design***	**Skills: students will be able to** ● **describe VSEPR theory** ● **explain the Shape of molecules with the help of VSEPR theory** ● ***explain how the shape and bond angles of the molecules helps chemists predict their interactions in the body.*** ● ***the importance of VSEPR theory in the field of drug design***
Perspectives: **chemical bonding and physical properties of materials.** **Bonding theory VSEPR theory**	

explain the Shape of molecules with the help of VSEPR theory
explain how the shape and bond angles of the molecules helps chemists predict their interactions in the body.
the importance of VSEPR theory in the field of drug design

Activity # 7
Materials Needed:

1. Whiteboard or blackboard
2. Markers or chalk
3. Projector or screen (optional, for displaying 3D molecular structures)
4. Handouts with practice problems or case studies related to drug design

Stage 1 - Introduction

- Begin the activity by introducing the concept of the VSEPR theory and its role in understanding molecular geometries.
- Explain that the VSEPR theory predicts the three-dimensional shapes of molecules based on the repulsion between electron pairs in the valence shell of atoms.
- Emphasize that the knowledge of molecular geometries is essential in drug design to understand how drugs interact with biological targets.

Stage 2 - Collaborative Exploration (Duration: 20 min)

- Divide the students into small groups (3-4 students per group).
- Provide each group with molecular models or 3D structures of different drug molecules or biological targets (if available).
- Instruct the groups to use the VSEPR theory to determine the molecular geometries of the provided molecules.
- Encourage students to discuss and analyze how the molecular geometry affects the drug's interactions with its target.

Stage 3 - Group Discussions and Presentations

- Ask each group to present their findings to the class, focusing on the importance of VSEPR theory in drug design.
- Prompt students to explain how the molecular geometry influences the drug's binding interactions, specificity, and activity.
- Encourage other students to ask questions and engage in discussions about the presented drug molecules and their geometries.

Stage 4 - Case Studies or Practice Problems

- Provide handouts with additional case studies or practice problems related to drug design and molecular geometries.
- Instruct the students to work on these problems individually or in groups.
- Foster critical thinking and problem-solving skills as they apply the VSEPR theory to drug design scenarios.

Note for Teachers:

- Facilitate student interactions and discussions during the collaborative exploration and group presentations.
- Use real-life drug design examples or case studies to illustrate the practical application of the VSEPR theory.
- Encourage students to think critically about the relationship between molecular geometries and drug activity.

Note for Students:

- Work collaboratively with your group to explore the molecular geometries of drug molecules.
- Prepare to present your findings and insights to the class during the group discussions.
- Engage actively in case studies or practice problems to reinforce your understanding of the importance of VSEPR theory in drug design.

<table>
<tr><td colspan="2">Domain: Domain B: Physical Chemistry</td></tr>
<tr><td colspan="2">Standard:
Apply the principles of thermochemistry to calculate heat transfer and changes in enthalpy.
Describe the laws of thermodynamics and their application in chemical systems.</td></tr>
<tr><td colspan="2">Student Learning Outcomes: Enable students to understand and apply Hess's Law to calculate enthalpy changes for chemical reactions through hands-on exploration and group discussions.
Apply Hess’s Law to calculate enthalpy changes in a reaction carried out in multiple steps.</td></tr>
<tr><td>Knowledge: students will get information about
the principles of thermochemistry to calculate heat transfer and changes in enthalpy.
the laws of thermodynamics and their application in chemical systems.</td><td>Skills: Enable students
to understand Hess’s Law to calculate enthalpy changes for chemical reactions
Apply Hess’s Law to calculate enthalpy changes in a reaction carried out in single and multiple steps reaction.</td></tr>
<tr><td colspan="2">Perspectives:
the principles of thermochemistry to calculate heat transfer and changes in enthalpy.
the laws of thermodynamics and their application in chemical systems.
to understand Hess’s Law to calculate enthalpy changes for chemical reactions
Apply Hess’s Law to calculate enthalpy changes in a reaction carried out in single and multiple steps reaction.</td></tr>
<tr><td colspan="2">Activity# 8
Materials Needed:
Whiteboard or blackboard
Markers or chalk
Chemicals for conducting three different chemical reactions (e.g., magnesium ribbon, hydrochloric acid, copper oxide, etc.)
Calorimeter or Styrofoam cups for measuring heat changes (optional but recommended)
Thermometer
Safety goggles and lab coats</td></tr>
</table>

Stage 1 - Introduction to Hess's Law

- Begin the activity by introducing the concept of Hess's Law and its significance in calculating enthalpy changes.
- Explain that Hess's Law states that the total enthalpy change for a reaction is independent of the reaction pathway and depends only on the initial and final states.
- Emphasize that it allows us to calculate enthalpy changes indirectly by using known enthalpy changes of other reactions.

Stage 2 - Experimental Setup

- Divide the students into small groups (3-4 students per group).
- Provide each group with the necessary chemicals and equipment to conduct three different chemical reactions, each with a known enthalpy change.
- Instruct the groups to conduct the reactions and measure the heat changes using a calorimeter or Styrofoam cups.

Stage 3 - Calculating Enthalpy Changes

- After the reactions are completed, guide the groups to calculate the enthalpy changes for each reaction based on the measured heat changes.
- Instruct the students to record their results and make sure they understand the calculations.

Stage 4 - Applying Hess's Law

- Once the groups have calculated the enthalpy changes for each reaction, explain how to apply Hess's Law to find the enthalpy change for a target reaction.
- Provide a target reaction and guide the students to use the known enthalpy changes of the three reactions they conducted to calculate the enthalpy change for the target reaction.

Stage 5 - Group Discussions and Presentations

- Ask each group to present their findings and results to the class, explaining how they applied Hess's Law to calculate the enthalpy change for the target reaction.
- Encourage other students to ask questions and engage in discussions about the application of Hess's Law.

Note for Teachers:

- Facilitate student interactions and discussions during the experimental setup and group presentations.
- Provide guidance and support as needed, especially during the application of Hess's Law to calculate enthalpy changes.

Note for Students:

- Work collaboratively with your group during the experimental setup and calculations.
- Prepare to present your findings and insights to the class during the group presentations.
- Engage actively in discussions to understand the application of Hess's Law in calculating enthalpy changes.

Domain: **Domain B: Physical Chemistry**	
Standard: Explain the relationship between concentration of reactants or products and the position of equilibrium.	
Student Learning Outcomes: Enable students to understand the relationships between different equilibrium constants (Kp, Kc, and Kx) for chemical reactions through hands-on exploration and collaborative discussions. Determine the relationship between different equilibrium constants (Kc) for the same reaction at the same temperature Write the equilibrium expression for a given chemical reaction in terms of concentration, K_c, partial pressure, number of moles and mole fraction.	
Knowledge: students will get concept of Chemical equilibrium **the equilibrium expression for a given chemical reaction in terms of concentration** **Equilibrium constant and the position of equilibrium.** **the relationships between different equilibrium constants (Kp, Kc, and Kx) for chemical reactions**	**Skills:** **students will be able to** **write the equilibrium expression for a given chemical reaction in terms of concentration** **predict the position of equilibrium.** **Write the relationships between different equilibrium constants (Kp, Kc, and Kx) for chemical reactions**
Perspectives:	

Chemical equilibrium with example
the equilibrium expression for a given chemical reaction in terms of concentration
Equilibrium constant and the position of equilibrium.
the relationships between different equilibrium constants (Kp, Kc, and Kx) for chemical reactions

Activity # 9

Materials Needed:

1. Whiteboard or blackboard
2. Markers or chalk
3. Chemicals for conducting two reversible chemical reactions (e.g., the reaction between iron chloride and silver nitrate to form iron nitrate and silver chloride)
4. Apparatus for measuring pressures and concentrations (e.g., pressure gauges, volumetric flasks)
5. Safety goggles and lab coats

Stage 1 - Introduction

- Begin the activity by introducing the concept of equilibrium constants (Kp, Kc, and Kx) and their significance in understanding the state of equilibrium for chemical reactions.
- Explain that Kp is the equilibrium constant expressed in terms of partial pressures of gases, Kc is the equilibrium constant expressed in terms of molar concentrations, and Kx is the equilibrium constant expressed in terms of other properties, such as activities or solubilities.

Stage 2 - Experimental Setup

- Divide the students into small groups (3-4 students per group).
- Provide each group with the necessary chemicals and equipment to conduct two reversible chemical reactions.
- Instruct the groups to set up the reactions and measure the equilibrium concentrations for both reactions.

Stage 3 - Calculating Equilibrium Constants

- After the reactions have reached equilibrium, guide the groups to calculate the equilibrium constants (Kp and Kc) for each reaction based on the measured concentrations and pressures.
- Instruct the students to record their results and make sure they understand the calculations.

Stage 4 - Applying the Relationship between Equilibrium Constants

- Once the groups have calculated the equilibrium constants for both reactions, explain the relationship between Kp and Kc for reactions involving gases and how to convert between them using the ideal gas law.
- Provide a sample reaction involving gases and guide the students to convert the equilibrium constant (Kc) to Kp using the appropriate equation.

Stage 5 - Group Discussions and Presentations

- Ask each group to present their findings and results to the class, including the calculated equilibrium constants and their relationship for the reactions they conducted.
- Encourage other students to ask questions and engage in discussions about the relationships between different equilibrium constants.

Note for Teachers:

- Facilitate student interactions and discussions during the experimental setup and group presentations.
- Provide guidance and support as needed, especially during the calculation of equilibrium constants and their relationships.

Note for Students:

- Work collaboratively with your group during the experimental setup and calculations.
- Prepare to present your findings and insights to the class during the group presentations.
- Engage actively in discussions to understand the relationships between different equilibrium constants.

Domain: **Domain B: Physical Chemistry**
Standard: Discuss the use of buffers to control pH, including the relationship between buffer capacity and the concentration of buffer components.
Student Learning Outcomes: Enable students to understand the concept of buffer solutions and calculate their pH through hands-on exploration and collaborative discussions. calculate the pH of buffer solutions in given appropriate data

Knowledge: Enable students to understand • **the concept of buffer solutions** • **calculate their pH of solutions**	**Skills:** **students will be able** • **To define the buffer solutions** • **calculate their pH of solutions**

Perspectives:

Acid base concept
pH, concentration of H ion concentration
the concept of buffer solutions
buffer solution is a mixture of a weak acid and its conjugate base or a weak base and its conjugate acid.

calculate their pH of solutions

Activity # 10

Materials Needed:

1. Whiteboard or blackboard
2. Markers or chalk
3. pH meter or pH indicator paper
4. Chemicals to prepare buffer solutions (e.g., acetic acid and sodium acetate)
5. Beakers or containers for preparing buffer solutions
6. Calculators

Stage 1 - Introduction

- Begin the activity by introducing the concept of buffer solutions and their significance in maintaining a stable pH.
- Explain that a buffer solution is a mixture of a weak acid and its conjugate base or a weak base and its conjugate acid.
- Emphasize that buffer solutions resist large changes in pH when small amounts of acid or base are added.

Stage 2 - Experimental Setup

- Divide the students into small groups (3-4 students per group).
- Provide each group with the necessary chemicals and equipment to prepare buffer solutions of different concentrations.
- Instruct the groups to prepare buffer solutions using a weak acid (e.g., acetic acid) and its conjugate base (e.g., sodium acetate).

Stage 3 - pH Measurement

- After preparing the buffer solutions, guide the groups to measure the pH of each solution using a pH meter or pH indicator paper.
- Instruct the students to record their pH measurements and make sure they understand how to use the pH meter or indicator paper.

Stage 4 - Calculating pH of Buffer Solutions

- Explain to the students how to calculate the pH of a buffer solution using the Henderson-Hasselbalch equation: $pH = pKa + \log([A^-]/[HA])$.
- Provide the pKa value for the weak acid used in the buffer solutions and the concentrations of the conjugate base and weak acid.
- Instruct the groups to calculate the pH of their buffer solutions using the Henderson-Hasselbalch equation.

Stage 5 - Group Discussions and Presentations

- Ask each group to present their findings and results to the class, including the calculated pH values for their buffer solutions.

- Encourage other students to ask questions and engage in discussions about buffer solutions and pH calculations.

Note for Teachers:

- Facilitate student interactions and discussions during the experimental setup and pH measurements.
- Provide guidance and support as needed, especially during the calculation of pH for buffer solutions.

Note for Students:

- Work collaboratively with your group during the experimental setup and pH calculations.
- Prepare to present your findings and insights to the class during the group presentations.
- Engage actively in discussions to understand the concept of buffer solutions and pH calculations.

Domain: **Domain E: Organic Chemistry**	
Standard: Perform basic retro-synthetic analysis to deduce the starting materials for the synthesis of a target molecule.	
Student Learning Outcomes: Enable students to practice retrosynthetic analysis by breaking down complex molecules into simpler starting materials through hands-on exploration and collaborative discussions. Explain the concept of retro-synthesis and its application in organic synthesis.	
Knowledge: **Enable students to understand** ● **the retrosynthetic analysis.** ● **The application of retro-synthesis in organic synthesis.**	**Skills:** **students will be capable to** ● **Explain the retrosynthetic analysis.** ● **apply retro-synthesis in organic synthesis.**
Perspectives: ● **the retrosynthetic analysis.** ● **The application of retro-synthesis in organic synthesis.**	

Activity # 11
Materials Needed:

1. Whiteboard or blackboard
2. Markers or chalk
3. Handouts with complex molecules and their retrosynthetic analysis
4. Organic chemistry model kits (optional but recommended)
5. Safety goggles and lab coats

Stage 1 - Introduction to Retrosynthesis

- Begin the activity by introducing the concept of retrosynthesis and its significance in organic chemistry.
- Explain that retrosynthesis is a strategic process to break down complex molecules into simpler starting materials or building blocks.
- Emphasize that retrosynthetic analysis is a crucial skill for designing efficient and practical synthesis routes in organic chemistry.

Stage 2 - Retrosynthetic Analysis Practice

- Divide the students into small groups (3-4 students per group).
- Provide each group with handouts containing complex molecules and their retrosynthetic analysis.
- Instruct the groups to analyze the given molecules and perform retrosynthetic analysis to identify potential starting materials or intermediates.

Stage 3 - Organic Chemistry Model Kit Activity

- If available, provide organic chemistry model kits to the groups for a hands-on activity.
- Instruct the groups to use the model kits to visualize the retrosynthetic analysis and build the identified starting materials or intermediates.

- Encourage students to discuss and explain their strategies for retrosynthesis and synthesis using the model kits.

Stage 4 - Group Discussions and Presentations

- Ask each group to present their retrosynthetic analysis and their chosen synthesis routes to the class.
- Encourage other students to ask questions and engage in discussions about the retrosynthetic analysis strategies.

Stage 5 - Conclusion and Wrap-up

- Summarize the key points about retrosynthesis and its importance in organic chemistry synthesis.
- Emphasize the practical applications of retrosynthetic analysis in drug design and other areas of organic chemistry.

Note for Teachers:

- Facilitate student interactions and discussions during the retrosynthetic analysis and model kit activity.
- Provide guidance and support as needed, especially during the analysis of complex molecules.

Note for Students:

- Work collaboratively with your group during the retrosynthetic analysis and model kit activity.
- Prepare to present your findings and insights to the class during the group discussions.
- Engage actively in discussions to understand the concept of retrosynthesis and its applications in organic chemistry.

Domain: Domain F: Empirical Data Collection and Analysis
Standard:

Compare and contrast different types of spectroscopy (e.g. infrared, ultraviolet-visible, nuclear magnetic resonance).
Use spectroscopic techniques to identify unknown compounds in a mixture.

Student Learning Outcomes: Enable students to understand the relationship between the colour of transition metal complexes and their UV-Vis spectra through hands-on exploration and collaborative discussions.
Predict the color of a transition metal complex from its UV/visible spectrum. **[SLO: C-12-F-19]**

Knowledge:	Skills:
Student will study the ● **different types of spectroscopy (e.g. infrared, ultraviolet-visible, nuclear magnetic resonance).** ● **Use of spectroscopic techniques to identify unknown compounds in a mixture.**	**Student will be able to** ● **Use of spectroscopic (e.g. infrared, ultraviolet-visible, nuclear magnetic resonance) techniques to identify unknown compounds in a mixture.**

Perspectives:
spectroscopy
types of spectroscopy infrared, ultraviolet-visible, nuclear magnetic resonance
introducing the concept of transition metal complexes and their characteristic colours.

UV-Vis spectra of different transition metal complexes

UV-Vis spectra and corresponding colours of transition metal complexes

Use of spectroscopic techniques to identify unknown compounds in a mixture.

Activity # 12
Materials Needed:

1. Whiteboard or blackboard
2. Markers or chalk
3. UV-Vis spectrophotometer or access to UV-Vis spectra of different transition metal complexes
4. Handouts with UV-Vis spectra and corresponding colours of transition metal complexes
5. Safety goggles and lab coats

Stage 1 - Introduction

- Begin the activity by introducing the concept of transition metal complexes and their characteristic colours.
- Explain that the colour of transition metal complexes arises due to the absorption of certain wavelengths of light in the UV-Vis region.
- Emphasize that the UV-Vis spectrum provides valuable information about the electronic transitions within the complexes, leading to their distinct colours.

Stage 2 - UV-Vis Spectrum Analysis

- Divide the students into small groups (3-4 students per group).
- Provide each group with handouts containing UV-Vis spectra of different transition metal complexes and their corresponding colours.
- Instruct the groups to analyze the provided spectra and identify the wavelength of maximum absorption (λmax) for each complex.

Stage 3 - Colour Prediction and Justification

- After analyzing the UV-Vis spectra, guide the groups to predict the colour of each transition metal complex based on their knowledge of the relationship between absorption and colour.
- Instruct the students to justify their predictions by relating them to the wavelengths of maximum absorption (λmax) and electronic transitions.

Stage 4 - Group Discussions and Presentations

- Ask each group to present their predictions and justifications for the colours of the transition metal complexes to the class.
- Encourage other students to ask questions and engage in discussions about the relationship between UV-Vis spectra and the colours of transition metal complexes.

Stage 5 - Conclusion and Wrap-up

- Summarize the key points about the relationship between the colour of transition metal complexes and their UV-Vis spectra.
- Emphasize the importance of UV-Vis spectroscopy in characterizing transition metal complexes and understanding their electronic transitions.

Note for Teachers:

- Facilitate student interactions and discussions during the UV-Vis spectrum analysis and colour prediction.
- Provide guidance and support as needed, especially in relating UV-Vis spectra to the colours of transition metal complexes.

Note for Students:

- Work collaboratively with your group during the UV-Vis spectrum analysis and colour prediction.
- Prepare to present your predictions and justifications to the class during the group discussions.
- Engage actively in discussions to understand the relationship between UV-Vis spectra and the colours of transition metal complexes.

GRADE 12

Domain: **Domain B: Physical Chemistry**

Standard: (Electrochemistry) Students should be able to:
Describe the principles of electrochemistry, including the movement of electrons in terms of oxidation and reduction in a chemical reaction.
Explain the concept of oxidation and reduction, including the role of electrons in these processes. .

Student Learning Outcomes: Enable students to balance chemical equations using changes in oxidation numbers through hands-on exploration and collaborative discussions.
Apply the concept of changes in oxidation numbers to balance chemical equations
Apply the concept of oxidation numbers in identifying oxidation and reduction reactions

Define the terms redox, oxidation, reduction, and disproportionation (in terms of electron transfer and changes in oxidation number)

Knowledge:	Skills:
Students will get knowledge of • **Electrochemistry** • **the oxidation and reduction reaction.** • **Balancing the chemical equations using changes in oxidation numbers**	**Students will be able to** • **Define the Electrochemistry** • **Define and identify the oxidation and reduction reaction.** • **Balance the chemical equations by oxidation numbers method**

Perspectives:

Definition of electrochemistry
Insulator & conductors
Electrochemical reaction
Oxidation number
Describe the principles of electrochemistry, including the movement of electrons in terms of oxidation and reduction in a chemical reaction.
Explain the concept of oxidation and reduction, including the role of electrons in these processes.

Activity #1

Materials Needed:

1. Whiteboard or blackboard
2. Markers or chalk
3. Handouts with chemical equations to balance
4. Calculators (optional but recommended)
5. Safety goggles and lab coats

Stage 1 - Introduction

- Begin the activity by introducing the concept of oxidation numbers and their role in balancing chemical equations.
- Explain that oxidation numbers indicate the charge of an atom in a compound and can help identify which elements are oxidized or reduced during a reaction.
- Emphasize that changes in oxidation numbers can be used to balance redox reactions.

Stage 2 - Handout with Unbalanced Equations

- Divide the students into small groups (3-4 students per group).
- Provide each group with handouts containing chemical equations that are not balanced.
- Instruct the groups to identify the elements undergoing oxidation and reduction and calculate the change in oxidation numbers for each element.

Stage 3 - Balancing Chemical Equations

- Guide the groups to use the changes in oxidation numbers to balance the chemical equations.
- Instruct the students to write half-reactions for oxidation and reduction, and then balance the atoms and charges on each side.
- Encourage the groups to collaborate and discuss their approaches to balancing the equations.

Stage 4 - Group Discussions and Presentations

- Ask each group to present their balanced chemical equations to the class, explaining their reasoning and steps in the balancing process.
- Encourage other students to ask questions and engage in discussions about the balancing of redox reactions.

Stage 5 - Conclusion and Wrap-up

- Summarize the key points about balancing chemical equations using changes in oxidation numbers.
- Emphasize the importance of understanding oxidation numbers in identifying redox reactions and balancing them effectively.

Note for Teachers:

- Facilitate student interactions and discussions during the equation balancing process.
- Provide guidance and support as needed, especially in understanding changes in oxidation numbers.

Note for Students:

- Work collaboratively with your group during the equation balancing process.
- Prepare to present your balanced chemical equations and explanations to the class during the group discussions.
- Engage actively in discussions to understand the concept of changes in oxidation numbers in balancing chemical equations.

Domain: **Domain F: Empirical Data Collection and Analysis**	
Standard: (Spectroscopy) Use spectroscopic techniques to identify unknown compounds in a mixture.	
Student Learning Outcomes: Enable students to understand the concept of degree of unsaturation (also known as the index of hydrogen deficiency) and how it can be used to determine the number of rings or multiple bonds in a molecule through hands-on exploration and collaborative discussions. Explain that the degree of unsaturation or index of hydrogen deficiency (IHD) can be used to determine from a molecular formula the number of rings or multiple bonds in a molecule.	
Knowledge: **Students will get knowledge of** **spectroscopic techniques to identify unknown compounds in a mixture.** **spectroscopic techniques to measure the degree of unsaturation (index of hydrogen deficiency) and how it can be used to determine the number of rings or multiple bonds in a molecule**	**Skills:** **Students will be able to** **identify unknown compounds in a mixture by spectroscopic methods.** **determine the number of rings or multiple bonds in a molecule by measure of the degree of unsaturation in organic compounds**
Perspectives: **spectroscopic techniques to identify unknown compounds in a mixture.** **spectroscopic techniques to measure the degree of unsaturation (index of hydrogen deficiency) and how it can be used to determine the number of rings or multiple bonds in a molecule.** useful for identifying aromatic compounds and compounds with double or triple bonds. **identify unknown compounds in a mixture by spectroscopic methods.** **determine the number of rings or multiple bonds in a molecule by measure of the degree of unsaturation in organic compounds**	
Activity # 2 **Materials Needed:** 1. Whiteboard or blackboard 2. Markers or chalk 3. Handouts with molecular structures of various organic compounds 4. Calculators (optional but recommended) 5. Safety goggles and lab coats	

Stage 1 - Introduction (Duration: 10 min)

- Begin the activity by introducing the concept of degree of unsaturation (DU) or index of hydrogen deficiency (IHD).
- Explain that DU is a value calculated from the molecular formula of an organic compound and provides information about the presence of rings or multiple bonds.
- Emphasize that DU is particularly useful for identifying aromatic compounds and compounds with double or triple bonds.

Stage 2 - Handout with Molecular Structures (Duration: 15 min)

- Divide the students into small groups (3-4 students per group).
- Provide each group with handouts containing molecular structures of various organic compounds (with their molecular formulas).
- Instruct the groups to calculate the degree of unsaturation for each compound using the given molecular formulas.

Stage 3 - Calculating Degree of Unsaturation (Duration: 20 min)

- Guide the groups to calculate the degree of unsaturation using the formula: $DU = (2 * C + 2 + N - H - X) / 2$, where C is the number of carbon atoms, N is the number of nitrogen atoms, H is the number of hydrogen atoms, and X is the number of halogen atoms.
- Instruct the students to record their calculated values and ensure they understand the process.

Stage 4 - Group Discussions and Presentations (Duration: 5 min)

- Ask each group to present their calculated degrees of unsaturation for the compounds to the class.
- Encourage other students to ask questions and engage in discussions about the concept of degree of unsaturation and its applications.

Stage 5 - Conclusion and Wrap-up (Duration: 5 min)

- Summarize the key points about degree of unsaturation and its significance in determining the number of rings or multiple bonds in a molecule.
- Emphasize the practical applications of DU in organic chemistry and structure determination.

Note for Teachers:

- Facilitate student interactions and discussions during the degree of unsaturation calculations.
- Provide guidance and support as needed, especially in understanding the concept and applying the formula.

Note for Students:

- Work collaboratively with your group during the degree of unsaturation calculations.
- Prepare to present your calculated values and explanations to the class during the group discussions.
- Engage actively in discussions to understand the concept of degree of unsaturation and its use in determining molecular structure.

Domain: **Domain F: Empirical Data Collection and Analysis**	
Standard: (Spectroscopy) The students will be able to: Analyze spectra to determine the presence and concentration of chemical species. Use spectroscopic techniques to identify unknown compounds in a mixture.	
Student Learning Outcomes: Enable students to interpret infrared (IR) spectra of organic compounds and deduce possible structural features through hands-on exploration and collaborative discussions. Deduce possible structures for organic compounds using IR spectrum and molecular formula (Examples: phenol, acetone, ethanol) Interpret an infrared (IR) spectrum of a simple molecule to identify functional groups	
Knowledge: **Students will learn to** **interpret infrared (IR) spectra of organic compounds and deduce possible structural features**	**Skills:** **Students will be able to** • **interpret infrared (IR) spectra of organic compounds** • **deduce possible structural features**
Perspectives:	

introducing the concept of infrared (IR) spectroscopy and its application in identifying organic compounds.

interpret infrared (IR) spectra of organic compounds and deduce possible structural features

IR spectroscopy provides information about the functional groups present in a compound based on the absorption of infrared radiation by specific chemical bonds.

functional groups and their characteristic peaks in the IR spectrum.

deduce possible structural features of the organic compounds based on the identified functional groups.

Instruct the students to consider the types of bonds and functional groups present in each compound.

Encourage the groups to collaborate and discuss their deductions of possible structures.

Activity # 3

Materials Needed:

1. Whiteboard or blackboard
2. Markers or chalk
3. Handouts with IR spectra of various organic compounds
4. Safety goggles and lab coats

Stage 1 - Introduction to IR Spectroscopy (Duration: 10 min)

- Begin the activity by introducing the concept of infrared (IR) spectroscopy and its application in identifying organic compounds.
- Explain that IR spectroscopy provides information about the functional groups present in a compound based on the absorption of infrared radiation by specific chemical bonds.

- Emphasize that different functional groups exhibit characteristic peaks in the IR spectrum.

Stage 2 - Handout with IR Spectra (Duration: 20 min)

- Divide the students into small groups (3-4 students per group).
- Provide each group with handouts containing IR spectra of various organic compounds.
- Instruct the groups to analyze the IR spectra and identify prominent peaks corresponding to specific functional groups.

Stage 3 - Deduction of Possible Structures (Duration: 20 min)

- Guide the groups to deduce possible structural features of the organic compounds based on the identified functional groups.
- Instruct the students to consider the types of bonds and functional groups present in each compound.
- Encourage the groups to collaborate and discuss their deductions of possible structures.

Stage 4 - Group Discussions and Presentations (Duration: 5 min)

- Ask each group to present their deductions of possible structures for the organic compounds to the class.
- Encourage other students to ask questions and engage in discussions about the interpretation of IR spectra.

Stage 5 - Conclusion and Wrap-up (Duration: 5 min)

- Summarize the key points about interpreting IR spectra and deducing possible structures of organic compounds.
- Emphasise the importance of IR spectroscopy in characterising and identifying organic molecules.

Note for Teachers:

- Facilitate student interactions and discussions during the interpretation of IR spectra and structure deduction process.

- Provide guidance and support as needed, especially in understanding the IR peaks and functional groups.

Note for Students:

- Work collaboratively with your group during the interpretation of IR spectra and deduction of possible structures.
- Prepare to present your deductions and explanations to the class during the group discussions.
- Engage actively in discussions to understand the concept of IR spectroscopy and its applications in organic compound analysis.

Domain: **Domain F: Empirical Data Collection and Analysis**

Standard: (NMR)
The students will be able to:
Describe the basic principles of NMR spectroscopy and explain how it is used to determine the structure of organic molecules
Distinguish between the different types of NMR spectra and interpret the information they provide

Student Learning Outcomes: Enable students to predict the chemical shift and splitting patterns of protons in a given molecule using NMR spectroscopy principles through hands-on exploration and collaborative discussions
predict the chemical shifts and splitting patterns of the protons in a given molecule
Use a H 1(superscript)(proton) NMR spectrum to deduce relative numbers of each type of proton present, the number of equivalent protons on the carbon atom adjacent to the one to which the given proton is attached,

analyze the different environments of protons present in a simple molecule using a 1H (proton) NMR spectrum

Knowledge:	Skills:
The students will understand: • **the basic principles of NMR spectroscopy a how NMR is used to determine the structure of organic molecules** • **interpretation of NMR spectrum** • **The concept of chemical shift and splitting patterns of protons in a given molecule**	**The students will be able to:** • **Describe the basic principles of NMR spectroscopy and explain how it is used to determine the structure of organic molecules** • **Distinguish between the different types of NMR spectra and interpret the information they provide**

- **Use a H^{1} NMR spectrum to deduce relative numbers of each type of proton present,**

Perspectives:

concept of nuclear magnetic resonance (NMR) the basic principles of NMR spectroscopy a how NMR is used to determine the structure of organic molecules
interpretation of NMR spectrum
NMR spectroscopy provides information about the local environments of hydrogen atoms (protons) in a compound
The concept of chemical shift and splitting patterns of protons in a given molecule

Activity # 4

Materials Needed:

1. Whiteboard or blackboard
2. Markers or chalk
3. Handouts with molecular structures of various organic compounds
4. NMR spectra charts or tables
5. Safety goggles and lab coats

Stage 1 - Introduction to NMR Spectroscopy

- Begin the activity by introducing the concept of nuclear magnetic resonance (NMR) spectroscopy and its application in studying organic molecules.
- Explain that NMR spectroscopy provides information about the local environments of hydrogen atoms (protons) in a compound.
- Emphasize that the chemical shift and splitting pattern of proton signals in the NMR spectrum can reveal valuable information about the molecular structure.

Stage 2 - Handout with Molecular Structures

- Divide the students into small groups (3-4 students per group).

- Provide each group with handouts containing molecular structures of various organic compounds.
- Instruct the groups to analyze the given structures and predict the chemical shift and splitting patterns for the protons in each compound.

Stage 3 - NMR Spectra Charts and Tables

- Provide NMR spectra charts or tables with typical chemical shift ranges for different types of protons (e.g., alkyl, alkene, aromatic, etc.) and their corresponding splitting patterns (e.g., singlet, doublet, triplet, etc.).
- Guide the groups to use these charts or tables to predict the chemical shifts and splitting patterns based on the local environments of the protons in the compounds.

Stage 4 - Group Discussions and Presentations

- Ask each group to present their predictions of chemical shifts and splitting patterns for the protons in the given compounds to the class.
- Encourage other students to ask questions and engage in discussions about NMR spectroscopy principles and proton analysis.

Stage 5 - Conclusion and Wrap-up

- Summarize the key points about predicting proton chemical shifts and splitting patterns using NMR spectroscopy.
- Emphasize the importance of NMR spectroscopy in structural elucidation and compound analysis.

Note for Teachers:

- Facilitate student interactions and discussions during the proton analysis and NMR spectroscopy principles.
- Provide guidance and support as needed, especially in understanding chemical shifts and splitting patterns.

Note for Students:

- Work collaboratively with your group during the proton analysis and NMR spectroscopy predictions.
- Prepare to present your predictions and explanations to the class during the group discussions.
- Engage actively in discussions to understand the concept of NMR spectroscopy and its applications in proton analysis.

Domain: **Domain F: Empirical Data Collection and Analysis**	
Standard: (NMR) The students will be able to: Distinguish between the different types of NMR spectra and interpret the information they provide	
Student Learning Outcomes: Enable students to distinguish between O-H and N-H protons in organic compounds through a proton exchange experiment using deuterium oxide (D2O) as a solvent, fostering hands-on exploration and collaborative discussions. describe the identification of O–H and N–H protons by proton exchange using D_2O	
Knowledge: **Enable will understand** **The Proton exchange method to distinguish different protons in an organic compound**	**Skills:** **Enable students to distinguish** **Different protons of organic compounds (i.e O–H and N–H protons) by proton exchange using D_2O**
Perspectives: introducing the concept of proton exchange and its significance in distinguishing between O-H and N-H protons in organic compounds. The Proton exchange method to distinguish different protons in an organic compound D2O, exchange of labile (easily exchangeable) protons with deuterium (D) occurs. rate of proton exchange varies depending on the nature of the proton and its chemical environment. identify the peaks corresponding to O-H and N-H protons and discuss their observations.	
Activity # 5	

Materials Needed:

1. Whiteboard or blackboard
2. Markers or chalk
3. Organic compounds with O-H and N-H protons (e.g., ethanol and methylamine)
4. Deuterium oxide (D2O)
5. NMR spectrometer (optional but recommended)
6. Safety goggles and lab coats

Stage 1 - Introduction to Proton Exchange Experiment (Duration: 10 min)

- Begin the activity by introducing the concept of proton exchange and its significance in distinguishing between O-H and N-H protons in organic compounds.
- Explain that when a compound is dissolved in D2O, exchange of labile (easily exchangeable) protons with deuterium (D) occurs.
- Emphasize that the rate of proton exchange varies depending on the nature of the proton and its chemical environment.

Stage 2 - Experimental Setup (Duration: 20 min)

- Divide the students into small groups (3-4 students per group).
- Provide each group with organic compounds containing O-H and N-H protons (e.g., ethanol and methylamine).
- Instruct the groups to dissolve a small amount of each compound in D2O and observe the changes in the NMR spectra.

Stage 3 - NMR Spectroscopy Analysis (Duration: 15 min)

- If available, guide the groups to analyze the NMR spectra of the dissolved compounds before and after proton exchange using an NMR spectrometer.
- Instruct the students to identify the peaks corresponding to O-H and N-H protons and discuss their observations.

Stage 4 - Group Discussions and Presentations (Duration: 5 min)

- Ask each group to present their findings and interpretations of the NMR spectra to the class.
- Encourage other students to ask questions and engage in discussions about proton exchange and NMR spectroscopy.

Stage 5 - Conclusion and Wrap-up (Duration: 5 min)

- Summarise the key points about identifying O-H and N-H protons through proton exchange using D2O as a solvent.
- Emphasise the practical applications of proton exchange experiments in NMR spectroscopy.

Note for Teachers:

- Facilitate student interactions and discussions during the proton exchange experiment and NMR spectroscopy analysis.
- Provide guidance and support as needed, especially in understanding the NMR spectra.

Note for Students:

- Work collaboratively with your group during the proton exchange experiment and NMR spectroscopy analysis.
- Prepare to present your findings and interpretations to the class during the group discussions.
- Engage actively in discussions to understand the concept of proton exchange and its role in NMR spectroscopy.

Domain:.**Domain F: Empirical Data Collection and Analysis**

Standard: (Materials)
The students will be able to:.
Discuss the extraction of materials from natural sources and the environmental impact of these processes.
Predict the outcome of chemical reactions involving materials, including oxidation-reduction reactions, precipitation reactions, and acid-base reactions.

Student Learning Outcomes: Enable students to understand the process of extracting metals from ores through a hands-on and interactive exploration of various extraction methods.
Explain the process of extracting metals from ores and alloying them to achieve desired characteristics

Knowledge: students will understand the process of extracting metals from its ores	**Skills:** **students will be able to** understand the process of extracting metals from its ores
Perspectives: Define ore concept of ore extraction and its significance in obtaining metals from their ores. Explain that ores are naturally occurring mineral deposits containing valuable metals that need to be extracted using suitable methods. Emphasize that different metals require different extraction techniques based on their reactivity and abundance. extracting metals from ores and the significance of different extraction methods.	
Activity # 6 **Materials Needed:** 1. Whiteboard or blackboard 2. Markers or chalk 3. Handouts with information on different extraction methods 4. Samples of ores (if available) 5. Safety goggles and lab coats **Stage 1 - Introduction to Ore Extraction** (Duration: 10 min) ● Begin the activity by introducing the concept of ore extraction and its significance in obtaining metals from their ores. ● Explain that ores are naturally occurring mineral deposits containing valuable metals that need to be extracted using suitable methods.	

- Emphasize that different metals require different extraction techniques based on their reactivity and abundance.

Stage 2 - Overview of Extraction Methods (Duration: 15 min)

- Divide the students into small groups (3-4 students per group).
- Provide each group with handouts containing information on different extraction methods such as smelting, roasting, leaching, and electrolysis.
- Instruct the groups to study the extraction methods and their applications for specific types of ores.

Stage 3 - Hands-on Exploration (Duration: 20 min)

- If available, provide samples of different ores to the groups for hands-on exploration.
- Instruct the students to observe the ores' properties, discuss their compositions, and consider which extraction method would be suitable for each ore.

Stage 4 - Group Discussions and Presentations (Duration: 5 min)

- Ask each group to present their findings and conclusions regarding the most appropriate extraction methods for the given ores.
- Encourage other students to ask questions and engage in discussions about ore extraction processes.

Stage 5 - Conclusion and Wrap-up (Duration: 5 min)

- Summarize the key points about the process of extracting metals from ores and the significance of different extraction methods.
- Emphasize the importance of sustainable and environmentally friendly extraction practices.

Note for Teachers:

- Facilitate student interactions and discussions during the hands-on exploration and group presentations.
- Provide guidance and support as needed, especially in understanding the extraction methods and their applications.

Note for Students:

- Work collaboratively with your group during the hands-on exploration and discussions about ore extraction.
- Prepare to present your findings and conclusions to the class during the group discussions.
- Engage actively in discussions to understand the concept of ore extraction and the various extraction methods used in metallurgy.

Domain: Domain E: Organic Chemistry

Standard: (Hydroxy Compounds) Students should be able to:
Explain the reaction mechanisms and products of alcohol reactions, including oxidation, esterification, and dehydration.

Student Learning Outcomes: Enable students to explore and understand the reactions of acyl chlorides through hands-on activities and collaborative discussions.
describe the reaction with acyl chlorides to form esters using ethyl ethanoate

Knowledge: students will get knowledge to	**Skills: students will be able to**
Explain the reaction mechanisms and products of Oxidation reaction esterification, and dehydration.	Explain the reaction mechanisms and products of Oxidation reaction esterification, and dehydration.

Perspectives:
by introducing the concept of acyl chlorides and their importance in organic synthesis.

Explain that acyl chlorides are reactive compounds containing the functional group -COCl.

Emphasize that acyl chlorides undergo various reactions with nucleophiles, alcohols, amines, and water.

Activity # 7

Materials Needed:

1. Whiteboard or blackboard
2. Markers or chalk
3. Handouts with information on reactions of acyl chlorides
4. Acyl chloride samples (e.g., acetyl chloride, benzoyl chloride)
5. Reagents for various reactions (e.g., alcohols, amines, water, etc.)
6. Safety goggles and lab coats

Stage 1 - Introduction to Acyl Chlorides

- Begin the activity by introducing the concept of acyl chlorides and their importance in organic synthesis.
- Explain that acyl chlorides are reactive compounds containing the functional group -COCl.
- Emphasize that acyl chlorides undergo various reactions with nucleophiles, alcohols, amines, and water.

Stage 2 - Overview of Acyl Chloride Reactions

- Divide the students into small groups (3-4 students per group).
- Provide each group with handouts containing information on different reactions of acyl chlorides.
- Instruct the groups to study the reactions and their mechanisms.

Stage 3 - Hands-on Exploration (Duration: 20 min)

- Provide acyl chloride samples and various reagents (alcohols, amines, water, etc.) to the groups.
- Instruct the students to perform simple reactions between acyl chlorides and the given reagents and observe the outcomes.

Stage 4 - Group Discussions and Presentations (Duration: 5 min)

- Ask each group to present their experimental results and observations to the class.
- Encourage other students to ask questions and engage in discussions about the reactivity of acyl chlorides.

Stage 5 - Conclusion and Wrap-up

- Summarize the key points about the reactions of acyl chlorides and their importance in organic synthesis.
- Emphasize the practical applications of acyl chloride reactions in various industries.

Note for Teachers:

- Facilitate student interactions and discussions during the hands-on exploration and group presentations.
- Provide guidance and support as needed, especially in understanding the reaction mechanisms.

Note for Students:

- Work collaboratively with your group during the hands-on exploration and discussions about acyl chloride reactions.
- Prepare to present your experimental results and observations to the class during the group discussions.
- Engage actively in discussions to understand the concept of acyl chloride reactions and their applications in organic chemistry.

Domain: **Domain E: Organic Chemistry**	
Standard: (Carbonyl Compounds) Students should be able to: Describe the structure and properties of carbonyl Compounds , including their characteristic functional groups.	
Student Learning Outcomes: Enable students to investigate and understand why amides are weaker bases than amines through hands-on activities and collaborative discussions. explain why amides are much weaker bases than amines	
Knowledge: **students will get knowledge about** **Amides** **Properties of amide i.e basic properties**	**Skills:** **Enable students to investigate** **The functional group Amides** **basic properties of amide**

Perspectives:
Amide & amine functional group
amides and amines and their differences in basicity.

amides and amines are both nitrogen-containing compounds, but their functional groups influence their basicity.

lone pair of electrons on the nitrogen atom in amines is more available for accepting protons, making them stronger bases than amides.

Activity # 8
Materials Needed:

1. Whiteboard or blackboard
2. Markers or chalk
3. Handouts with information on the basicity of amides and amines
4. Samples of amides (e.g., acetamide) and amines (e.g., methylamine)
5. pH indicator strips or pH meters
6. Safety goggles and lab coats

Stage 1 - Introduction to Amides and Amines

- Begin the activity by introducing the concept of amides and amines and their differences in basicity.
- Explain that amides and amines are both nitrogen-containing compounds, but their functional groups influence their basicity.
- Emphasize that the lone pair of electrons on the nitrogen atom in amines is more available for accepting protons, making them stronger bases than amides.

Stage 2 - Comparison of Basicity

- Divide the students into small groups (3-4 students per group).
- Provide each group with handouts containing information on the basicity of amides and amines.

- Instruct the groups to compare the basicity of amides and amines based on the provided information.

Stage 3 - Experimental Investigation

- Provide samples of amides (e.g., acetamide) and amines (e.g., methylamine) to the groups.
- Instruct the students to test the basicity of the samples using pH indicator strips or pH meters by measuring the pH of their aqueous solutions.

Stage 4 - Group Discussions and Presentations

- Ask each group to present their findings and conclusions regarding the basicity of amides and amines to the class.
- Encourage other students to ask questions and engage in discussions about the factors influencing basicity.

Stage 5 - Conclusion and Wrap-up

- Summarize the key points about the basicity of amides and amines and the reasons behind their differences.
- Emphasize the importance of understanding basicity in the context of organic chemistry and chemical reactivity.

Note for Teachers:

- Facilitate student interactions and discussions during the comparison of basicity and experimental investigation.
- Provide guidance and support as needed, especially in understanding the factors affecting basicity.

Note for Students:

- Work collaboratively with your group during the comparison of basicity and experimental investigation.
- Prepare to present your findings and conclusions to the class during the group discussions.
- Engage actively in discussions to understand the concept of basicity and the differences between amides and amines.

Domain: **Domain E: Organic Chemistry**

Standard: (Polymer) Students should be able to: Describe the structure and properties of polymers, including homopolymers and copolymers.

Student Learning Outcomes: Enable students to properties of PVC and Nylon through hands-on exploration and collaborative discussions
Explain the chemical processes and properties of PVC and nylon, and the applications of these polymers in understand the manufacturing process and the industry.

Knowledge:
Students will get information about
- **the structure and properties of polymers PVC and Nylon**

Skills:
Students will be able to
- **Explain the chemical processes and properties of PVC and nylon,**
- **describe the applications of these polymers in the industry**.

Perspectives:
Introduction of PVC and Nylon. Chemical formula
the chemical processes and properties of PVC and nylon,
the applications of these polymers in the industry.

Activity # 9

Materials Needed:

1. Whiteboard or blackboard
2. Markers or chalk
3. Handouts with information on the process and properties of PVC and Nylon
4. PVC and Nylon samples (if available)
5. Safety goggles and lab coats

Stage 1 - Introduction to PVC and Nylon

- Begin the activity by introducing the concept of PVC (Polyvinyl Chloride) and Nylon and their significance in the polymer industry.
- Explain that PVC is a synthetic polymer derived from vinyl chloride monomers, and Nylon is a synthetic polyamide.
- Emphasize the importance of these polymers in various applications due to their unique properties.

Stage 2 - Overview of Manufacturing Process

- Divide the students into small groups (3-4 students per group).
- Provide each group with handouts containing information on the manufacturing process of PVC and Nylon.
- Instruct the groups to study the processes and the chemical reactions involved in their production.

Stage 3 - Hands-on Exploration

- If available, provide samples of PVC and Nylon to the groups.
- Instruct the students to observe the physical properties of the samples and discuss their characteristics.

Stage 4 - Group Discussions and Presentations

- Ask each group to present their understanding of the manufacturing process and properties of PVC and Nylon to the class.
- Encourage other students to ask questions and engage in discussions about the applications and significance of these polymers.

Stage 5 - Conclusion and Wrap-up

- Summarize the key points about the manufacturing process and properties of PVC and Nylon.
- Emphasize the importance of these polymers in our daily lives and their contributions to various industries.

Note for Teachers:

- Facilitate student interactions and discussions during the exploration of PVC and Nylon.
- Provide guidance and support as needed, especially in understanding the manufacturing processes.

Note for Students:

- Work collaboratively with your group during the exploration of PVC and Nylon.
- Prepare to present your findings and explanations to the class during the group discussions.
- Engage actively in discussions to understand the concept of PVC and Nylon properties and their applications.

Domain: **Domain E: Organic Chemistry**

Standard: (Organic Synthesis)
The students will be able to:
Identify and name common organic functional groups and their physical and chemical properties.

Student Learning Outcomes: Enable students to understand the applications of artificial intelligence (AI) tools in the field of organic chemistry and their role in designing organic molecules through hands-on exploration and collaborative discussions.
Describe the use of Artificial Intelligence tools in designing organic molecules which may have the potential to be used as medicine. (Halicin can be used as an example)

Knowledge:	Skills:
Students will get information of **artificial intelligence tools** **the applications of artificial intelligence tools in the field of organic chemistry**	**Students will enable to understand** **artificial intelligence tools** **the applications of artificial intelligence tools in the field of organic chemistry**

Perspectives
introducing the concept of artificial intelligence (AI) and its growing impact on various industries, including chemistry.
Explain that AI tools are being increasingly used in organic chemistry to aid in the design and optimization of new molecules with specific properties.

importance of AI in accelerating the drug discovery process and materials science.

Activity # 10

Materials Needed:

1. Whiteboard or blackboard
2. Markers or chalk
3. Handouts with information on AI tools in organic molecule design
4. Computers or tablets with internet access (optional but recommended)
5. Safety goggles and lab coats

Stage 1 - Introduction to AI Tools in Organic Molecule Design

- Begin the activity by introducing the concept of artificial intelligence (AI) and its growing impact on various industries, including chemistry.
- Explain that AI tools are being increasingly used in organic chemistry to aid in the design and optimization of new molecules with specific properties.
- Emphasize the importance of AI in accelerating the drug discovery process and materials science.

Stage 2 - Overview of AI Applications in Organic Molecule Design

- Divide the students into small groups (3-4 students per group).
- Provide each group with handouts containing information on AI tools and their applications in organic molecule design.
- Instruct the groups to study the applications of AI in different areas of organic chemistry.

Stage 3 - Hands-on Exploration

- If possible, provide access to computers or tablets with internet access.
- Instruct the students to explore online resources or AI platforms that demonstrate the use of AI tools in designing organic molecules.

- Encourage them to perform virtual experiments and visualize how AI algorithms can predict molecular properties and optimize structures.

Stage 4 - Group Discussions and Presentations

- Ask each group to present their findings and insights on the use of AI tools in organic molecule design to the class.
- Encourage other students to ask questions and engage in discussions about the potential benefits and limitations of AI in this context.

Stage 5 - Conclusion and Wrap-up

- Summarize the key points about the applications of AI in designing organic molecules and its impact on the field of organic chemistry.
- Emphasize the importance of keeping up with advancements in technology to stay informed about cutting-edge tools in the scientific community.

Note for Teachers:

- Facilitate student interactions and discussions during the exploration of AI tools in organic molecule design.
- Provide guidance and support as needed, especially in understanding the AI applications.

Note for Students:

- Work collaboratively with your group during the exploration of AI tools in organic molecule design.
- Prepare to present your findings and insights to the class during the group discussions.
- Engage actively in discussions to understand the concept of AI applications in organic chemistry and its potential implications.

Domain: **Domain F: Empirical Data Collection and Analysis**
Standard: (NMR)

The students will be able to: Explain how carbon-13 NMR spectra provide unique information about the structure of organic molecules. Analyze carbon-13 NMR spectra to deduce the structure of simple organic compounds and recognize common spectral patterns in the spectra of different types of compounds.
Student Learning Outcomes: Enable students to predict the number of peaks in a 13C NMR spectrum for a given molecule based on the carbon environment of different carbon atoms through hands-on exploration and collaborative discussions. Predict the number of peaks in a 13C NMR spectrum for a given molecule. Use a C13 NMR spectrum to deduce possible structures of a simple molecule.

Knowledge: Students will get knowledge to **Understand C NMR** **The use of C NMR to predict structure of molecules**	**Skills:** **Students will be able to** ● **Use a C ^{13} NMR spectrum to describe the structure of molecule,**

Perspectives: NMR and C ^{13} NMR chemical shift values 13C NMR spectroscopy and its application in organic compound analysis The use of C NMR to predict structure of molecules Use a C ^{13} NMR spectrum to describe the structure of molecule NMR spectra its interpretation
Activity # 11 **Materials Needed:** 1. Whiteboard or blackboard 2. Markers or chalk 3. Handouts with information on 13C NMR spectroscopy and chemical shift values 4. Molecular models or drawings of organic compounds (if available) 5. Safety goggles and lab coats

Stage 1 - Introduction to 13C NMR Spectroscopy

- Begin the activity by introducing the concept of 13C NMR spectroscopy and its application in organic compound analysis.
- Explain that 13C NMR spectroscopy provides information about the carbon environments in a molecule, and each unique carbon environment gives rise to a distinct peak in the spectrum.
- Emphasize that the number of peaks in a 13C NMR spectrum is determined by the different types of carbon atoms present in the compound.

Stage 2 - Overview of Carbon Environments

- Divide the students into small groups (3-4 students per group).
- Provide each group with handouts containing information on different carbon environments and their corresponding chemical shift values in 13C NMR spectra.
- Instruct the groups to study the different types of carbon atoms and their characteristic chemical shifts.

Stage 3 - Hands-on Exploration

- Provide molecular models or drawings of organic compounds to the groups.
- Instruct the students to identify the different types of carbon environments in the given molecules and predict the number of peaks they would expect to see in the 13C NMR spectrum.

Stage 4 - Group Discussions and Presentations

- Ask each group to present their predictions of the number of peaks in the 13C NMR spectrum for the given molecules to the class.
- Encourage other students to ask questions and engage in discussions about the factors influencing the chemical shifts and peak numbers.

Stage 5 - Conclusion and Wrap-up

- Summarize the key points about predicting the number of peaks in a 13C NMR spectrum based on carbon environments.
- Emphasize the importance of 13C NMR spectroscopy in identifying carbon connectivity and functional groups in organic compounds.

Note for Teachers:

- Facilitate student interactions and discussions during the exploration of 13C NMR spectroscopy.
- Provide guidance and support as needed, especially in understanding the different carbon environments.

Note for Students:

- Work collaboratively with your group during the exploration of 13C NMR spectroscopy and carbon environments.
- Prepare to present your predictions and explanations to the class during the group discussions.
- Engage actively in discussions to understand the concept of 13C NMR spectroscopy and its applications in organic compound analysis.

Domain: Atomic Structure

Standard: Students should be able to:

- Describe the structure of atoms, including the nucleus and electron shells.
- Explain the concept of atomic number and its relationship to the number of protons in an atom.
- Describe the arrangement of electrons in the electron shells and explain how this arrangement affects the chemical properties of an atom.
- Discuss the principles of isotopes, including atomic mass and isotopic abundance.
- Explain the concept of ionization and describe the formation of ions.

Benchmark I: Students can describe the structure of atoms, including the protons, neutrons, and electrons.

Student Learning Outcomes

1. Describe the structure of atom as a central positively charged nucleus surrounded by negatively charged cloud of electrons due to electrostatic attraction

- understand that, unlike orbits, shells and subshells are energy levels of electrons and a bigger shell implies greater energy and average distance from nucleus

- electrons are quantum particles with probabilistic paths whose exact paths and locations cannot be mapped (with reference to the uncertainty principle)

- nucleus is made of protons and neutrons held together by strong force

- understand that atomic model is a model to aid understanding and if an atom were to be 'photographed' it will be a fuzzy cloud

2. Identify and describe protons, neutrons and electrons in terms of their relative charges and relative masses

3. Understand the terms atomic and proton number; mass and nucleon number

4. Describe the distribution of mass and charge within an atom

5. Describe the behavior of beams of protons, neutrons and electrons moving at the same velocity in an electric field

6. Determine the numbers of protons, neutrons and electrons present in both atoms and ions given atomic or proton number, mass or nucleon number and charge

7. Explain qualitatively the variations in atomic radius and ionic radius across a period and down a group

8. Define the term isotope in terms of numbers of protons and neutrons

9. Understand the notation for isotopes

10. State that and explain why isotopes of the same element have the same chemical properties and different physical properties, limited to mass and density

11. Understand the terms: shells, sub-shells and orbitals, principal quantum number (n), ground state, limited to electronic configuration

12. Describe the number of orbitals making up s, p and d sub-shells, and the number of electrons that can fill s, p and d sub-shells

13. Describe the order of increasing energy of the sub-shells within the first three shells and the 4s and 4p sub-shells

14. Describe the electronic configurations to include the number of electrons in each shell, sub-shell and orbital

15. Explain the electronic configurations in terms of energy of the electrons and inter-electron repulsion

16. Determine the electronic configuration of atoms and ions given the atomic or proton number and charge, using either of the following conventions

17. Understand and use the electrons in boxes notation

18. Describe and sketch the shapes of s and p orbitals

19. Describe a free radical as a species with one or more unpaired electrons

20. Understand the concept of ionization energy and its trends across a period and down a group of the Periodic Table and the variation in successive ionization energies of an element

21. Understand that ionization energies are due to the attraction between the nucleus and the outer electron

22. Explain the factors influencing the ionization energies of elements in terms of nuclear charge, atomic/ionic radius, shielding by inner shells and sub-shells and spin-pair repulsion

23. Deduce the electronic configurations of elements using successive ionization energy data

24. Deduce the position of an element in the Periodic Table using successive ionization energy data

25. Perform calculations involving non-integer relative atomic masses and abundance of isotopes from given data, including mass spectra.

26. Understand the concept of emission spectra and use it to deduce the electronic configuration of elements.

Knowledge:
Students will know…
- How an atom is structured and the subatomic particles it contains.
- Arrangement of electrons in the subshells and the electronic configurations of the elements.
- The quantum theory understanding of atomic orbitals and radius.

Students will understand…
- Terms like quantization, isotopes, orbitals, and ionization.

Skills:
Students will be able to…
- Describe atoms as the fundamental particles of elements and their structures.
- Understand the phenomena of ionization and its relation with the atomic number and atomic size.
- Evaluate the forces involved at subatomic levels and estimate their relative magnitudes.
- Explain the stability of an atomic structure.
- Discuss the theory of atomic structure starting from Rutherford, continuing through Bohr and explaining the modern quantum theory.

Perspectives
- Evolution of atomic theory: This perspective highlights the historical development of atomic theory, from ancient Greek philosopher Democritus' idea of atoms to John Dalton's law of definite proportions and atomic theory. For example, students can learn about how the discovery of electrons by J.J. Thomson, and the subsequent development of atomic models by Niels Bohr and Ernest Rutherford, led to a deeper understanding of the structure of atoms.
- Atom-molecule interaction: This perspective focuses on how the properties of atoms and molecules interact and affect the properties of materials. For example, students can learn about the effect of electron configuration on the reactivity of elements, and how the arrangement of atoms in a molecule affects its shape and reactivity.
- Modern applications: This perspective emphasizes the practical applications of atomic theory and its impact on fields such as medicine, energy, and technology. For example, students can learn about the role of atomic theory in the development of X-ray crystallography and its use in determining the structures of biological molecules, as well as the use of nuclear reactions in nuclear power plants and medical imaging.

Learning Activities

1. **Creating a Trending Periodic Table**

Objective: To understand the trends in the periodic table and their relation to the electron configuration of elements.

Materials:
- 18 elements with their atomic number, symbol, and electronegativity
- 18 blank periodic table sheets for each student or group
- Colored pens or markers

Procedure:
- Give each student or group a set of data for 18 elements, including their atomic number, symbol, and electronegativity.
- Instruct students to use the data to create their own periodic table, organizing the elements based on their electronegativity trend.
- Encourage students to use different colors or symbols to represent the trends and make their periodic table visually appealing.
- Once they have finished creating their periodic table, have them present their work to the class and discuss their reasoning behind their arrangements.
- As a class, compare the different periodic tables and discuss the similarities and differences in the arrangements.
- Facilitate a discussion on the trends in electronegativity and their relationship to the electron configuration of elements.

Assessment:
- Observe student participation and engagement during the presentation and discussion of their periodic tables.
- Evaluate their periodic table for accuracy and the use of color or symbols to represent the trends in electronegativity.
- Assess their understanding of the relationship between electronegativity and electron configuration through class discussions and questions.

Expected Results:
Students will have a clear understanding of the trends in electronegativity in the periodic table.
Students will have the ability to apply their understanding of electron configuration to explain the trends in electronegativity.
Students will have engaged in higher-order thinking skills through the creation and presentation of their periodic table.

Demonstration

Students can observe the spectra of different elements and compare the patterns to determine the elements' electronic configurations. The teacher can lead a discussion about how spectroscopy is used in real-world chemistry applications. In case a laser and grating are not available, spectroscopic data can be used.

Domain: Chemical Bonding

Standard: Students should be able to:

- Explain the concept of chemical bonding and describe the different types of bonds, including ionic, covalent, and metallic bonds.
- Discuss the factors that affect bond strength, including bond length and bond energy.
- Describe the properties of molecular compounds and how they are affected by the type of bond they contain.
- Apply the principles of chemical bonding to explain the behavior of substances in different physical states.
- Describe the role of chemical bonding in chemical reactions, including the formation and breaking of bonds.

Benchmark I: Students can describe the types of chemical bonds, including ionic, covalent, and metallic bonds.

Student Learning Outcomes

1. Define electronegativity as the power of an atom to attract electrons to itself

2. Explain the factors influencing the electronegativities of the elements in terms of nuclear charge, atomic radius and shielding by inner shells and sub-shells

3. State and explain the trends in electronegativity across a period and down a group of the Periodic Table

4. Use the differences in Pauling electronegativity values to predict the formation of ionic and covalent bonds

5. Define ionic bonding as the electrostatic attraction between oppositely charged ions (positively charged cations and negatively charged anions) and describe ionic bonding including the examples of sodium chloride, magnesium oxide and calcium fluoride

6. Define metallic bonding as the electrostatic attraction between positive metal ions and delocalized electrons

7. Define covalent bonding as electrostatic attraction between the nuclei of two atoms and a shared pair of electrons, describe covalent bonding in molecules, use the concept of hybridization to describe sp, sp2 and sp3 orbitals and use bond energy values and the concept of bond length to compare the reactivity of covalent molecules

8. State and explain the shapes of, and bond angles in, molecules by using VSEPR theory, predict the shapes of, and bond angles in, molecules and ions analogous to those specified

9. Describe the types of van der Waals' force:

- instantaneous dipole – induced dipole (id-id) force, also called London dispersion forces

- permanent dipole – permanent dipole (pd-pd) force, including hydrogen bonding

- Hydrogen bonding as a special case of permanent dipole – permanent dipole force between molecules where hydrogen is bonded to a highly electronegative atom

10. Describe hydrogen bonding, limited to molecules containing N–H and O–H groups, including ammonia and water as simple examples

11. Use the concept of hydrogen bonding to explain the anomalous properties of H2O (ice and water)

12. Use the concept of electronegativity to explain bond polarity and dipole moments of molecules

13. Describe van der Waals' forces as the intermolecular forces between molecular entities and explain the types of van der Waals' force

14. State that, in general, ionic, covalent and metallic bonding are stronger than intermolecular forces

15. Use dot-and-cross and lewis dot diagrams to show the arrangement of electrons in covalent molecules and ions.

Knowledge:
Students will know…

- The concept of chemical bonding and the various types of bonds atoms form.
- The relative strengths of atomic bonds and the forces involved in each of them.
- The concept of covalent bonds and the different theories that explain the shapes, strengths, and lengths of these bonds.
- The concept of Hydrogen Bonding and its involvement in maintaining the structure of molecules like water and ammonia.

Students will understand…

- Terms like Electronegativity, Van der Waals' forces, Dipoles, and Hybridization.

Skills:
Students will be able to…

- Explain the structure of different compounds formed as a result of chemical bonding and compare their relative strengths and characteristics.
- Explain the geometry of molecules and understand different shapes the atoms can arrange in based on the kind of bond involved.
- Compare the theories concerning the formation of covalent bonds and their postulates and predictions about the bond length and strength.
- Evaluate the involved intermolecular forces between molecules and their role in determining the physical and chemical properties of the compounds.

Perspectives

- The development of chemical bonding theories: From early bonding theories like the ionic and covalent models to more recent developments like orbital hybridization and molecular orbitals, understanding the evolution of chemical bonding theories can provide a deeper appreciation for how our understanding of chemical bonds has changed over time.
- The role of chemical bonding in determining the properties of matter: Chemical bonding plays a key role in determining the properties of matter, such as melting and boiling points, reactivity, and solubility. Understanding how different bonding types can lead to different properties can help students understand why different materials behave in unique ways.

- The interplay between chemical bonding and the environment: Chemical bonding can play a role in environmental issues, such as air and water pollution, soil contamination, and climate change. Understanding the mechanisms behind chemical bonding reactions can help students appreciate the impact of these reactions on the environment and the potential for human actions to mitigate these effects.

Learning Activities

Trend in electronegativity across period 3

Materials:
- Sodium (Na), Magnesium (Mg), Aluminum (Al), Silicon (Si), Phosphorus (P), Sulfur (S), Chlorine (Cl), Argon (Ar)
- Beaker of distilled water
- Litmus paper
- Test tubes
- Pipettes

Procedure:
- Prepare 10 test tubes, one for each element in the list above.
- Label each test tube with the name of the element.
- Using a pipette, add 1 mL of distilled water to each test tube.
- Add a small piece of each element to each test tube, starting with Sodium and ending with Calcium.
- Observe the reaction of each element with water and record the results in a data table.
- Use the results to create a periodic table with the elements arranged in order of increasing electronegativity.

Element | Reaction with water | Electronegativity
Na | Releases hydrogen gas, forms a basic solution | Lowest by using isolated wooden box and gloves
Mg | Releases hydrogen gas, forms a basic solution | Low
Al | No reaction | Moderate
Si | No reaction | Moderate
P | Reacts to form a neutral solution | Moderate
S | Reacts to form an acidic solution | High
Cl | Reacts to form an acidic solution | Highest
Ar | No reaction | N/A
K | Releases hydrogen gas, forms a basic solution | Low
Ca | No reaction | Moderate

Expected Results:
- Sodium and Potassium will react with water to release hydrogen gas, forming a basic solution.
- Magnesium will also release hydrogen gas, but to a lesser extent than Sodium and Potassium.
- Aluminum and Silicon will not react with water.
- Phosphorus will react with water to form a neutral solution.
- Sulfur will react with water to form an acidic solution.

- Chlorine will react with water to form an acidic solution, showing the highest electronegativity.
- Argon is an inert gas and will not react with water.

Conclusion:
The trend in electronegativity of period 3 elements can be observed by their behavior in aqueous solutions. The electronegativity of the elements increases from Sodium to Chlorine, with Sodium having the lowest electronegativity and Chlorine having the highest. This activity demonstrates the relationship between electronegativity and the ability of an element to attract electrons from other atoms in a chemical bond.

Domain: Environmental Chemistry
Topic: Atmosphere

Standard: Students should be able to:

- Describe the composition and structure of the Earth's atmosphere, including the major gases and trace gases.
- Explain the role of the atmosphere in the Earth's climate, including the greenhouse effect.
- Discuss the sources and effects of atmospheric pollutants, including greenhouse gases and air pollutants.
- Apply the principles of chemical reactions to explain the formation and removal of atmospheric pollutants.
- Describe the role of atmospheric chemistry in environmental chemistry and its impact on air quality and climate.

Benchmark I: Demonstrate an understanding of the composition, structure and functions of the Earth's atmosphere, including the role of atmospheric gases, pollutants and greenhouse effect.

Student Learning Outcomes

1. Understanding of the properties and composition of air and the factors that affect air quality

2. Knowledge of the sources and effects of air pollution, including both natural and human-caused pollutants including Carbon monoxide (CO), Sulfur dioxide (SO_2),Nitrogen oxides (NO_x), Particulate matter (PM), Ozone (O_3), Lead (Pb), Mercury (Hg), Polycyclic aromatic hydrocarbons (PAHs), Persistent organic pollutants (POPs), Greenhouse gases (such as carbon dioxide, methane, and nitrous oxide), Chlorofluorocarbons (CFCs) and other ozone-depleting substances, Volatile organic compounds (VOCs), Heavy metals (such as lead, mercury, and cadmium))

3. Familiarity with the methods and techniques used to measure and monitor air quality

4. Understanding of the impact of human activities on the atmosphere, including the effects of burning fossil fuels and deforestation

5. Knowledge of the chemical reactions and processes that occur in the atmosphere, such as the formation of smog and acid rain

6. Familiarity with the laws and regulations related to air quality and the measures used to control air pollution

7. Ability to analyze data and interpret air quality measurements and trends

8. Understanding of the link between air quality and human health and the ability to evaluate the potential health risks associated with air pollution

9. Knowledge of the technologies and strategies used to reduce air pollution and improve air quality, such as emissions control and renewable energy sources.

10. Ability to design experiments and collect data to test hypotheses about air quality

11. Familiarity with the global scale problems of air pollution, such as global warming and the greenhouse effect.

12. Ability to think critically about the economic, social and political issues related to air pollution and air quality management.

13. Familiarity with light pollution, microplastics, noise pollution, toxic waste and plastic pollution.

Knowledge:

Students will know…

- Composition of air and the leading sources of air pollutants in the atmosphere.
- The sources of these pollutants and their effects on human and atmospheric health.
- Chemical reactions between the pollutants and the atmospheric gases to produce smog and acid rain.
- Economic and environmental issues underlying changing air quality.

Skills:

Students will be able to…

- Make suggestions about fighting climate change.
- Discuss the main sources of air pollution and make recommendations for fixing them.
- Explain the harmful effects of smog and acid rain and present precautionary measures to avoid these effects.
- Provide suggestions on making energy sources more renewable.

Perspectives

- Understanding the composition and structure of the Earth's atmosphere:
  Discuss how the composition of the Earth's atmosphere changes with altitude, including the presence of trace gases such as ozone and carbon dioxide.
  In the context of Pakistan, mention the impact of increasing industrialization and urbanization on air quality, specifically in cities such as Karachi and Lahore.
- Exploring the role of the atmosphere in the Earth's climate:

Discuss how the atmosphere plays a crucial role in regulating the Earth's temperature through the greenhouse effect.
Mention the impact of climate change on the monsoon patterns in Pakistan, and its effects on agriculture and water availability.

- Examining the sources and effects of atmospheric pollutants:
  Discuss the sources of air pollutants, including industrial emissions, vehicular emissions, and natural sources.
  In the context of Pakistan, mention the air pollution crisis in cities like Lahore, which is caused by the high levels of vehicular and industrial emissions.
- Applying the principles of chemical reactions to explain the formation and removal of atmospheric pollutants:
  Discuss the chemical reactions that lead to the formation of air pollutants, such as the reaction of nitrogen oxides and volatile organic compounds to form ground-level ozone.
  Mention the efforts being made to combat air pollution, such as the installation of scrubbers in power plants and the promotion of alternative modes of transportation.

Learning Activities

1. **Measuring the Amount of Oxygen in the Air**

Objective: To measure the amount of oxygen in the air using common household materials.

Materials:

Small, clear plastic bottle with a lid
Water
Alka-Seltzer/Aspirin tablet
Scale
Ruler

Procedure:
Fill the bottle with water, leaving about 1 inch of air space at the top.
Measure the initial volume of air in the bottle using the ruler. Record the volume in milliliters.
Crush an Alka-Seltzer/Aspirin tablet into a fine powder and add it to the water in the bottle.
Quickly screw the lid on the bottle, making sure it is tightly sealed.
Observe the reaction of the Alka-Seltzer with the water, which will produce carbon dioxide gas. The carbon dioxide gas will displace the air in the bottle, increasing the volume of the bottle.
Measure the final volume of the bottle using the ruler. Record the volume in milliliters.
Calculate the volume of air displaced by subtracting the initial volume from the final volume.
The volume of air displaced is directly proportional to the amount of oxygen in the air. You can use the following conversion factor to determine the percentage of oxygen in the air:
(Volume of air displaced / Total volume of the bottle) * 100 = % oxygen in the air.

Precautions:
Make sure to crush the Alka-Seltzer tablet into a fine powder before adding it to the water to maximize the amount of carbon dioxide produced.
Make sure to screw the lid on the bottle tightly to prevent the carbon dioxide from escaping.

The reaction between Alka-Seltzer and water can get quite vigorous, so be careful not to spill any of the solution while measuring the final volume of the bottle.

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Science Bob. (n.d.). How much Oxygen is in the Air? [online] Available at: https://www.sciencebob.com/how-much-oxygen-is-in-the-air/ [Accessed 9 Feb 2023].

2. **Investigating Air Pollution with Bumper Stickers**

Objective: To study the effects of air pollution on the environment and understand the role of nitrogen oxides and sulfur dioxide in the formation of acid rain.

Materials:

Bumper stickers or adhesive labels
Markers
Plastic bags
Ruler or measuring tape

Procedure:
Cut out a bumper sticker or adhesive label and place it inside a plastic bag. Seal the bag.
Label the bag with the date and time it was collected.
Place the bag in an area with high air pollution, such as near a busy road or industrial area.
Leave it there for 24 hours.
Remove the bag and examine the bumper sticker. Observe any discoloration or changes in color.
Repeat steps 1 to 4 in a clean air area, such as a park or a countryside.
Compare the bumper stickers from the two different locations and discuss the differences in discoloration or color changes.
Measure the size of any discolored areas on both stickers and compare the results.

Analysis:
The bumper stickers will change color due to the presence of nitrogen oxides and sulfur dioxide in the air. The discoloration will be more pronounced in the bumper sticker from the area with high air pollution. The discoloration of the bumper sticker is a result of acid rain formation caused by the nitrogen oxides and sulfur dioxide in the air.

Conclusion:
This activity helps students understand the effects of air pollution on the environment and the role of nitrogen oxides and sulfur dioxide in the formation of acid rain. Students will appreciate the importance of reducing air pollution to protect our environment.

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Lesson Plans on Conducting Experiments in the Lab

Chemistry Experiment – Grade 09

Subject: Chemistry	Level: Grade 09	Topic: Investigating the pH of common household substances
Name of teacher: xxx		Duration: 80 min.

Objectives

By the end of this lab students will be able to;

- To understand the concept of acids and bases and the pH scale.
- To learn how to use a pH meter to measure the pH of different household substances.
- To compare and analyze the pH values of various household substances.
- To relate the pH values of the substances to their acidic or basic nature.

Materials and Apparatus

- pH meter or pH indicator paper
- Distilled water
- 0.1 M Hydrochloric acid (HCl)
- 0.1 M Sodium hydroxide ($NaOH$)
- Vinegar
- Baking soda
- Lemon juice
- Soap solution
- Salt
- Tap water
- 10 small beakers
- Dropper
- Stirring rod

Methodology	Duration and Resources
Introduction: 1. Introduction to Acids and Bases: The teacher will begin the lesson by introducing the concept of acids and bases to the students. They will explain the difference between acids and bases, the pH scale, and how to measure pH using indicators. 2. Safety Procedures: The teacher will go over the safety procedures for the lab, including wearing goggles and aprons, handling chemicals carefully, and cleaning up spills. 3. Demonstration: The teacher will perform a demonstration of an acid-base reaction using a universal indicator to show how the pH changes. 4. Discussion: The students will discuss the demonstration and predict what will happen when different acids and bases are mixed. 5. Objective: The teacher will explain the objective of the lab, which is to determine the pH of common household substances. **Main Activity:** 1. Materials: The teacher will provide each group with a set of materials, including a pH meter or paper, various household substances, and a data sheet.	15 minutes

2. Procedure: The teacher will explain the procedure for testing the pH of the substances. The students will use the pH meter or paper to test the pH of each substance and record the results on their data sheet. 3. Discussion: As the students are testing the substances, the teacher will ask questions to encourage critical thinking and discussion. They may ask about the properties of the substances that affect pH, or the potential uses of the substances in industry or everyday life. 4. Analysis: Once all the substances have been tested, the students will analyze the data to identify patterns and draw conclusions. They may be asked to create graphs or charts to represent the data.	05 Minutes 25 Minutes 15 Minutes
Wrap-up: 1. Conclusion: The teacher will ask the students to share their findings and discuss what they learned. They will summarize the main concepts of the lab, including the difference between acids and bases, how to measure pH, and the pH of common household substances. 2. Applications: The teacher will discuss some real-world applications of pH testing, such as testing the pH of swimming pools, soil, or drinking water. 3. Clean-up: The students will clean up their workstations, dispose of any materials according to safety procedures, and return any equipment to the teacher.	10 Minutes 10 Minutes

Assessment	Students will be assessed based on their participation in the experiment and their ability to accurately measure the pH of the substances. Students will be asked to write a short reflection on the experiment, highlighting the importance of understanding the pH of household substances.
Extensions	Students can further investigate the effect of adding an acid or base to a neutral substance. Students can explore the pH values of different fruits and vegetables and their importance in nutrition. Students can also investigate the effect of pH on the growth of plants.

Teacher's Reflections	
What went as planned?	What needs Improvements?

Chemistry Experiment – Grade 10

Subject: Chemistry	Level: Grade 10	Topic: Acid-base Titration
Name of teacher: xxx		Duration: 80 min.

Objectives

By the end of this lab students will be able to;

- To learn the principles of acid-base titration
- To practice the technique of titration
- To determine the concentration of an unknown acid or base
- Practice recording and analyzing data.
- Develop teamwork and communication skills.

Materials and Apparatus

- 0.1 M sodium hydroxide (NaOH)
- 0.1 M hydrochloric acid (HCl)
- Phenolphthalein indicator
- Burette
- Pipette
- Conical flask
- Distilled water

Methodology	Duration and Resources
Introduction: 1. The teacher will begin by introducing the concept of acid-base titration to the students. 2. The teacher will explain the importance of titration in various fields of chemistry and its significance in determining the concentration of a solution. 3. The teacher will also explain the basic principles of acid-base titration, including the use of indicators, burettes, and conical flasks.	15 minutes
Main Activity: *Phase 01:* 1. The teacher will provide each student with a burette, pipette, and conical flask. 2. The teacher will demonstrate the proper technique for filling a burette and how to properly dispense the titrant into the solution. 3. Each student will be provided with a solution of either 0.1 M NaOH or 0.1 M HCl. 4. The student will use a pipette to measure a specific volume of the unknown solution into a conical flask. 5. The student will then add a few drops of phenolphthalein indicator to the solution. *Phase 02:* 6. The student will begin the titration process by slowly adding the titrant (NaOH or HCl) to the solution while stirring the solution.	25 Minutes

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7. The student will continue adding the titrant until the endpoint is reached (the point at which the indicator changes color).
8. The student will record the volume of the titrant used to reach the endpoint.
9. The student will repeat the process three times to ensure accurate results.

Wrap-up:

1. The teacher will lead a discussion on the results obtained by the students and the importance of accuracy in titration.
2. The teacher will provide a brief explanation of how to calculate the concentration of the unknown solution using the data collected during the titration.
3. The students will be asked to calculate the concentration of the unknown solution using the data collected.
4. The teacher will explain the importance of using standardized solutions in titration and the consequences of not doing so.

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25 Minutes

15 Minutes

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Assessment	Assessment of student learning can be conducted through the following means: • The teacher will evaluate the accuracy and completeness of the data collected by the students. • The teacher will assess the students' ability to correctly calculate the concentration of the unknown solution. • The teacher will ask follow-up questions to assess the students' understanding of the principles of acid-base titration.
Extensions	If time permits, the following extension activities can be used to further enhance student's knowledge and skills: • The teacher can provide additional challenges to the students by using more complex titrations or unknown solutions of varying concentrations. • The students can explore the use of different indicators in acid-base titrations and their effect on the accuracy of results. • The students can explore the use of different types of titrations, such as redox or precipitation titrations, and their applications in various fields of chemistry.

Teacher's Reflections	
What went as planned?	What needs Improvements?

Chemistry Experiment – Grade 11

Subject: Chemistry	Level: Grade 11	Topic: Determination of the Stoichiometry of a Chemical Reaction
Name of teacher: xxx		Duration: 80 min.

Objectives

By the end of this lab students will be able to;

- To understand the concept of stoichiometry and how it is used in chemical reactions
- To determine the stoichiometry of a chemical reaction experimentally
- To develop skills in using a balance and other laboratory equipment
- To learn to write balanced chemical equations
- Practice recording and analyzing data.
- Develop teamwork and communication skills.

Materials and Apparatus

- Magnesium ribbon
- Hydrochloric acid solution (1M)
- Burette
- Graduated cylinder
- Erlenmeyer flask
- Bunsen burner
- Wire gauze
- Tripod stand
- Stopwatch
- Safety goggles
- Lab apron

Methodology	Duration and Resources
Introduction: 1. The teacher will introduce the topic of stoichiometry and its importance in chemistry. 2. The teacher will explain the concept of a chemical reaction and balanced chemical equations. 3. The teacher will demonstrate how to write balanced chemical equations.	15 minutes
Main Activity: *Phase 01:* 1. The teacher will divide the students into groups of two. 2. Each group will be provided with the necessary equipment and chemicals. 3. The students will weigh a 5 cm length of magnesium ribbon and record its mass. 4. The students will add 25 mL of 1M hydrochloric acid to an Erlenmeyer flask and place the flask on top of a wire gauze. 5. The students will carefully add the weighed magnesium ribbon to the flask and start the stopwatch.	30 Minutes

6. The students will observe the reaction and record the time it takes for the reaction to complete (when no more bubbles are seen).	
Phase 02: 7. The students will carefully rinse and fill a burette with sodium hydroxide (NaOH) solution. 8. The students will titrate the excess hydrochloric acid in the flask with the NaOH solution until the reaction is neutralized. 9. The students will record the volume of NaOH solution used. 10. The students will repeat the experiment two more times to obtain an average time and volume of NaOH solution used. 11. The students will calculate the stoichiometry of the reaction using the balanced chemical equation and their experimental results.	25 Minutes
Wrap-up: 1. The teacher will guide the students through the process of calculating the stoichiometry of the reaction. 2. The students will share their results and discuss any discrepancies in their data. 3. The teacher will summarize the key concepts learned in the lab activity.	10 minutes

Assessment	Assessment of student learning can be conducted through the following means: ● The students' laboratory reports will be assessed based on the completeness and accuracy of their data, calculations, and conclusions. ● The students' participation in the activity and their ability to work collaboratively and safely in the laboratory will also be evaluated.
Extensions	If time permits, the following extension activities can be used to further enhance student's knowledge and skills: ● The students can investigate how changing the concentration of hydrochloric acid or magnesium affects the reaction rate and stoichiometry. ● The students can also explore other chemical reactions and determine their stoichiometry using the same methodology.

Teacher's Reflections	
What went as planned?	What needs Improvements?

Chemistry Experiment – Grade 12

Subject: Chemistry	Level: Grade 12	Topic: Determination of the Enthalpy Change of a Chemical Reaction
Name of teacher: xxx		Duration: 80 min.

Objectives

By the end of this lab students will be able to;

- To understand the concept of enthalpy change and its significance in chemical reactions
- To learn the technique of calorimetry to measure the enthalpy change of a chemical reaction
- To apply the knowledge of enthalpy change to calculate the heat of reaction and understand its implications
- Practice recording and analyzing data.
- Develop teamwork and communication skills.

Materials and Apparatus

- 2 Styrofoam cups
- Thermometer
- Weighing balance
- Stirrer
- Graduated cylinder
- Hot plate
- Magnesium ribbon
- Hydrochloric acid (HCl)
- Distilled water

<table>
<tr><th>Methodology</th><th>Duration and Resources</th></tr>
<tr><td>Introduction:
1. Begin by introducing the concept of enthalpy change and its significance in chemical reactions.
2. Explain the principle of calorimetry and its use in measuring the enthalpy change of a chemical reaction.
3. Discuss the difference between exothermic and endothermic reactions.</td><td>15 minutes</td></tr>
<tr><td>Main Activity:
Phase 01:
1. Instruct the students to weigh approximately 0.2 grams of magnesium ribbon and place it in a Styrofoam cup.
2. Add 50 mL of 1.0 M hydrochloric acid to the cup and stir gently.
3. Take the initial temperature of the solution and record it.
4. Monitor the temperature for 2-3 minutes until the reaction is complete.
5. Take the final temperature of the solution and record it.

Phase 02:
6. Repeat the experiment twice or more to ensure accuracy. (if possible)</td><td>30 Minutes</td></tr>
</table>

7. After completing the experiment, have students calculate the enthalpy change of the reaction using the equation: $$\Delta H = q/n$$ where ΔH is the enthalpy change, q is the heat absorbed or released by the reaction, and n is the number of moles of the limiting reactant. 8. Discuss the implications of the calculated enthalpy change and its relationship with the heat of reaction. **Wrap-up:** 1. Summarize the key concepts covered in the lab activity. 2. Ask students to share their observations and experiences during the experiment. 3. Emphasize the importance of understanding enthalpy change in chemical reactions and its applications in various industries.	20 Minutes 15 Minutes

Assessment	Students will be assessed on their understanding of the principles of calorimetry and their ability to calculate the enthalpy change of a chemical reaction. The accuracy and precision of their experimental data will also be evaluated.
Extensions	Students can research and present on the practical applications of enthalpy change in industries such as food, pharmaceuticals, and energy production. Students can also explore other chemical reactions and calculate their enthalpy change using the techniques learned in the lab activity.

Teacher's Reflections	
What went as planned?	What needs Improvements?