National School Curriculum

INSTRUCTIONAL GUIDE FOR CHEMISTRY

CLASSES XI & XII

Department of Curriculum and Professional Development
Ministry of Education, Royal Government of Bhutan

“Your parents, relatives, and friends would be very proud of what you have achieved. At your age, to have completed your studies is your personal accomplishment. Your knowledge and capabilities are a great asset for the nation. I congratulate you for your achievements. Finally, your capabilities and predisposition towards hard work will invariably shape the future of Bhutan. You must work with integrity, you must keep learning, keep working hard, and you must have the audacity to dream big.”

- ***His Majesty Jigme Khesar Namgyel Wangchuck***

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Published by:

Department of Curriculum and Professional Development (DCPD), Ministry of Education, Royal Government of Bhutan, Thimphu

Provisional Edition, 2021

First Edition, 2022

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ISBN No: 978-99936-0-662-8

FOREWORD

COVID-19 has caused unforgiving disruptions in the public education all over the world, and brought about threats of fragmentation in the society due to disparities in accessibility and connectivity in many systems. In Bhutan too, continuity of education and learning has been severely affected as a result of sporadic nationwide school closures, restrictions and health protocols. The disruptions exposed the limitation of the existing ideologies and practices in education. This has deprived children living in poverty worldwide, who rely on the physical settings of their schools for educational materials and guidance, of the learning and other essential educational services. Cognizant of the global trend to embrace the competency based learning as education for the 21st century, the current priority of the Government is to transform the knowledge and textbook based learning to competency-based learning through open source and experiential learning.

In the new normal education, human interaction and well-being is a priority. Technology, particularly digital technology that enables communication, collaboration and learning across distance, is a formidable tool though not a panacea but a source of innovation and expanded potentials. As we embrace this exceptional opportunity to transform the education, it is imperative to reimagine the organization of our educational institutions and learning environments. In the post COVID 19 era, we must prioritize the development of the whole person not just the acquisition of academic knowledge. Inspiration for the change can be drawn from the 1996 Delors report, *Learning the treasure within*. Its four pillars of learning as "learning to know", "learning to do", "learning to be", and "learning to live together" are the current global ethos of teaching and learning. Therefore, curricula must be increasingly perceived as an integrated, theme based and problem-based orientation that allows learners develop a strong base of knowledge about one's self and about the world, and find purpose of life and be better able to participate in social and political milieu.

The National School Curriculum is, not just a mere response to the pandemic, but also the culmination of the curriculum reform work for the last four years by the erstwhile Royal Education Council. It is an attempt to transform education from the teaching of "what" to learning of "how" and "why" towards empowering learners with the transversal competencies and the 21s t century skills, and preparing them to be lifelong learners. In tandem with this initiative, we are optimistic that the paradigm shift in Chemistry education orients our education process in empowering young generation with the Chemistry mind-set and disposition, and skills towards nurturing nationally rooted and globally competent citizens.

With this guide, we are optimistic that our learners and teachers are ushered through a life enriching experiential Chemistry education.

Tashi Delek

(Tashi Namgyal)
DIRECTOR

Introduction

The conventional education, which is predominantly knowledge based and examination centred teaching and learning has been the time old practices. Stress of this model is on the learning of textual information perceived by educators important for the grade. On the other hand, with the advancement in ICT, the world is flooded with such information, which is widely read by all at their leisure. What learners cannot acquire from the multiple sources are the skills, values and change of behaviour, which are crucial in facilitating learners realise their potential to be socially responsible and productive individuals, and optimise their contribution in the nation building processes – economic, social, and political development. In the contemporary world, textbook based, knowledge-based education compromises the development of psychomotor and affective domains of learning, affecting the holistic development and psychosocial wellbeing of learners.

The pandemic situation also explicated that the old ways of working, teaching and learning, and lifestyle have limitations. Consequently, new ways of how we work and live, teach and learn, stay connected are the contemporary traditions. In this context, an overhaul of how we think and do are imperative, not a choice. The transformation of classroom instruction from the teacher centred to that of learner centred learning however calls for the following adjustment, or even the overhaul of some of the practises.

i. Reduction of learning content to facilitate deep learning as opposed to the width of the teaching and learning through active engagement of learners.
ii. Integration of ICT as tools and ends of the learner's education. The use of multimedia and ICT software are commonly utilised in the teaching and learning as innovation to introduce variation in stimuli, and sustain learner's interest and zeal in learning.
iii. Adoption of theme-based learning content facilitates in broadening the horizon of learning beyond the four walls, and stimulates the transfer of the learnt concepts to the learner's immediate environment. This arrangement makes learners aware of the realities of the social, political, economic and cultural practices and ethos of the society. Being aware of the immediate environment of the scopes and challenges, learners are sensitised to the opportunities and issues.
iv. Consideration to ground the curriculum design and instruction approaches on the epistemological theories is imperative to facilitate deep learning as opposed to factual learning. The selection and use of them, however, is subject to the nature of the subject. For instance, constructivism is more apt for science, while connectivism may be relevant for languages and ICT curricula to facilitate deep learning and inspire the generation of new knowledge and ideas.
v. Active engagement of learners is imperative for competency-based education and learning. Inevitably, summative assessment has limitations in gauging the progressive development of the learner. This is achieved

objectively by the use of the continuous formative assessment (CFA). However, if summative assessment evidence is used to provide feedback to help learners in learning, it can serve as one of the techniques of CFA.

The curriculum is grounded on the wisdom and principles of competency-based learning, built on reality of the immediate environment, and the belief system of the society, promotes the personalised learning; fosters life enriching experiences, which inspires youth to generate new knowledge and create new ideas to innovate as young scientists or enterprising individuals.

Towards this, learning is facilitated through the "Instructional Guide" with learners taking responsibility for their learning. Roles of teachers are facilitation, guide, evaluation in the course of learners' active engagement, and assess the performance for improvement and enhance learner's learning. Therefore, the NSC Chemistry Instructional Guide (Chemistry IG) is an attempt to transform education from the teaching of "what" to learning of "how" and "why" towards empowering learners with the transversal competencies and the 21st century skills, and preparing them to be lifelong learners.

Purpose of the Instructional Guide

In the National School Curriculum, deep learning, which is synonymous to "less is more" is facilitated with the use of Instructional Guide for each subject and specific class. The content of the instruction in the guide for respective subjects are aligned with the subject's curriculum framework. Therefore, the Chemistry IG is purported to achieve the following objectives towards facilitating uninterrupted teaching and learning:

i. Strengthen competency based learning and experiential learning to foster sensitivity to realities of life and environment.
ii. Strengthen blended learning and flipped classroom with multimedia, digital pedagogies and ICT devices and websites as tools and ends of the learning.
iii. Prioritise learning content with emphasis on creating time and space for deep learning and raise sensitivity of the realities of the world around them through active engagement of learners.
iv. Facilitate the use of CFA for learning using diverse appropriate assessment techniques and tools commensurate with individual differences in learning, and gather evidence to guide planning of educational programs and activities for learners.
v. Promote inclusive learning through the blended learning which facilitates learning anywhere, any time with the learner being responsible for the learning.
vi. Inspire teachers to assume the roles of facilitation, guide, motivator and evaluator.
vii. Guide both teachers and parents in facilitating learning of their children.

The experiential and personalised learning practices are widely used around the world and are grounded on different models. One of such models that suits the current situation and expectation of education for the 21st century is the ADDIE model (Analyse, Design, Develop, Implement and Evaluate).

Table of Contents

1. CURRICULUM CONTENT

1.1 Curriculum Content (Class XI)

1.1.1 Classifying Materials

Classifying materials is grouping materials based on their similar properties. Materials are classified in order to study their properties and identify common patterns among them. Under classifying materials, learners study atomic structure and chemical bonding.

Competencies:

- Analyse the historical development of different atomic models to interconnect the knowledge in understanding the behaviour of matter and the universe.

  Objective(s)

  Atomic Structure

  i. Explain the discovery of electrons, protons and neutrons after exploring the information through relevant sources.
  ii. Compare the properties of electron, proton and neutron in relation to their charge and mass.
  iii. Explain the modifications in the theories of atomic structure by designing Thomson's, Rutherford's, and Bohr's atomic models.
  iv. Compare isotopes, isobars, isotones and isosters in relation to atomic number and atomic mass after exploring the information through relevant sources.
  v. Calculate the relative atomic mass of an element in relation to relative abundance of isotopes using the mathematical data.
  vi. Narrate the significance of isotopes to day-to-day life.
  vii. Explain the differences between orbit and orbital using an analogy.
  viii. Interpret four quantum numbers to evaluate their significance.
  ix. Explain that the quantum model predicts that electrons do not occupy orbit but orbitals.
  x. Construct 2D/3D structure of *s, p* and *d* orbitals to highlight their shapes.
  xi. Write electronic configuration of the given elements using Aufbau's Principle, Pauli's exclusion principle and Hund's rule of maximum multiplicity.
  xii. Evaluate the importance of atom and atomic structure in explaining the mysteries of life and existence of the universe.
  xiii. Critique any atomic models and put forward a suggestive model

- Understand that the bonding of atoms form new substances that have different properties and geometries and significance of bonding in supporting all forms of life.

  Objective(s)

  Chemical Bonding

  i. Explain electrovalent bond and covalent bond with reference to electrovalency and covalency using simulation / video tutorial.

ii. Compare the properties of substances in relation to the nature of bonds such as ionic, covalent and dative bonds.
iii. Explain the causes of variable electrovalency, variable covalency and violation of octet rule after exploring the information through relevant sources.
iv. Explore limitations of Lewis concept of covalent bond using relevant sources.
v. Explain hybridisation of orbitals using an analogy.
vi. Construct 2D/3D structures of molecules to explain the shapes of sp, sp^2 and sp^3 molecules.
vii. Discuss VSEPR theory, VBT and MOT to explain the shape of molecules.
viii. Explain electronegativity, dipole moment and hydrogen bond and conditions for formation of hydrogen bond by using simulation /video tutorial.
ix. Calculate the polarity of bond in different molecules to predict their ionic character.
x. Explain the existence of partial covalent character in ionic compounds with reference to Fajan's rule.
xi. Explain metallic bond in the light of the electron-sea model by using simulation.
xii. Explore the historical evolution and properties of metals and their applications with the changing time.
xiii. Analyse the causes and the factors determining Van der Waal's force.
xiv. Relate chemical bonds with the properties of substances and their application in material science and significance in life.
xv. Compare the physical properties of molecules based on strength of Van der Waal's forces.

1.1.1.1 Atomic Structure

- Sub-atomic Particles (*Scope: properties of proton, neutron and electron, discovery of sub- atomic particles, charge on electron 'e/m ratio'*)
- Atomic models (*Scope: Thomson's model of atom, Rutherford's experiment and model, failure of Rutherford's atomic model, Bohr's model of the atom*)
- Atomic number and mass number (*Scope: definition of atomic number and mass number, explanation of isotopes, isobars, isotones, isosters with examples*)
- Relative atomic mass (*Scope: definition of relative atomic mass based on C-*12 *isotope, calculation of relative atomic mass of an element when relative abundances of its isotopes are given, calculation of relative molecular mass and relative formula mass from atomic masses*)
- Concept of atomic orbital (*Scope: definition of orbital, differences between orbit and orbital*)

- Quantum numbers (*Scope: description of four quantum numbers - principal quantum number, azimuthal quantum number, magnetic quantum number and spin quantum number, number of orbitals making up s-subshell, p-subshell and d-subshell, and the number of electrons that occupy s-subshell, p-subshell and d-subshell*)
- Shapes of orbitals (*Scope: description of shapes of s-orbital, p-orbital and d-orbital*)
- Energy level diagram for multi-electron atoms *(Scope: description of relative energies of s-orbitals, p-orbitals and d-orbitals for the quantum levels 1, 2, 3 and the 4s- and 4p-orbitals)*
- Filling of orbitals (*Scope: statement and application of Aufbau's principle, (n+l) rule, Pauli's exclusion principle, Hund's rule of maximum multiplicity, rule of half-filled and completely-filled orbitals*)
- Electronic configuration of elements (*Scope: electronic configurations of the atoms of elements up to atomic number 36*)
- Some exceptional electronic configurations (*Scope: study exceptional electronic configuration of elements*)

Learning Experiences:

Sub-atomic Particles and Atomic Models

The teacher may use Jigsaw method to deliver the lesson. The teacher divides the learners into three different expert teams (E1, E2 and E3) and makes the teams to explore on the discovery of electrons, protons and neutrons. The teacher splits the expert teams into jigsaw teams (J1, J2 and J3) and makes the learner to share in a team.

- The learner in expert team explores on the discovery of electron, proton and neutron using different sources.
- The learner in jigsaw team shares the discovery of electrons, protons and neutrons.
- The learner in team compares and discusses the properties of electron, proton and neutron in relation to their charge and mass.
- The learner comes back to the expert group and explores on Thomson's, Rutherford's, and Bohr's atomic models.
- The learner in Jigsaw group explains different modifications of atomic models.
- The learner in expert team designs three models of atom using chart / ChemDraw or any drawing tools and shares the models to the class.

Atomic Number, Mass Number and Relative Atomic Mass

The teacher may use blended learning to deliver the lesson. The teacher provides materials / simulations (*https://phet.colorado.edu/sims/html/isotopes-and-atomic-mass/latest/isotopes-and-atomic-mass_en.html*) / video links (*https://www.youtube.com/watch?v=gj6TgUwiBr0&t=29s* and *https://www.youtube.com/watch?v=1Uqo1guzD-I*) on isotopes, isotones and isosters in Google Classroom or any other learning platform two or three days before the lesson.

The learner reads the materials / uses video links provided by the teacher on isotopes, isotones and isosters.

- The learner prepares PowerPoint presentations on isotopes, isotones and isosters and the significance of isotopes in day-to-day life.
- The learner presents the work to the class for feedback and comment.
- The learner calculates the relative atomic mass of an element in relation to relative abundance of isotopes using the mathematical data provided by the teacher.
- The learner submits the work to the teacher for feedback and comment.

Concept of Atomic Orbital

The teacher may use Atkin and Karplus learning cycle to deliver the lesson. The teacher provides materials on the orbit and orbitals in Google Classroom or any other learning platform few days before the lesson.

Explore

- The learner reads the materials provided by the teacher.

Concept development

- The learner explains the differences between orbit and orbital using an analogy to the class. (*Refer Appendix 11 (a) for sample*)

Concept application

- The learner in team constructs 3D model of *s, p* and *d* orbitals to highlight their shapes.
- The learner shares the model of orbitals to the class for feedback and comment.
- The learner in team prepares video tutorial to explain the four quantum numbers and their significance.
- The learner shares the video tutorial in the social media.

Explore

- The learner explores the information on Aufbau's Principle, (n+l) rule, Pauli's exclusion principle and Hund's rule of maximum multiplicity using relevant sources.

Concept development

- The learner explains the above concepts to the class for comment and feedback.

Concept application

- The learner uses the simulation/video link (*https://www.youtube.com/watch?v=B3Q5a3q_5b0*) to write the correct electronic configuration of elements based on the concept of Aufbau Principle, (n+l) rule, Pauli's exclusion principle and Hund's rule of maximum multiplicity.
- The learner submits the work to the teacher for feedback and comment.

- The learner discusses the importance of atom and atomic structure in explaining the mysteries of life, existence of the universe, quantum computing, teleportation, etc.
- The learner shares the discussion in the school science corner.

Assessment:

- The teacher may use assessment techniques such as question-answer, DARTs (Directed Activities Related to Text), game, crossword puzzle, review, report writing etc. to assess the learner's conceptual understanding of atomic structure.
- The teacher may assess the learner's skills in collaboration, computation, presentation, information management, communication, differentiation, and creation while designing the model of orbital and exploring information on atomic structure.
- The teacher may assess the learner's scientific values and attitudes such as curiosity, intellectual honesty, perseverance etc.
- The teacher may design assessment tools such as rubric, checklist or rating scale to assess the learner and accordingly provide necessary intervention.
- For recording and reporting, refer National School Curriculum Framework (NSCF-2021)

Resources:

- REC Repository
- A Text Book of Chemistry Class XI (2015) - Macmillan publishers India Private Ltd.
- National School Curriculum Framework (NSCF-2021)
- Simulation link:
- Isotopes and atomic mass
  https://phet.colorado.edu/sims/html/isotopes-and-atomic-mass/latest/isotopes-and-atomic-mass_en.html
- Rutherford Scattering
  https://phet.colorado.edu/sims/html/rutherford-scattering/latest/rutherford-scattering_en.html

Challenge Your Thinking

1) (a) A sample of iron from a meteorite was found to contain the isotopes ^{54}Fe, ^{56}Fe and ^{57}Fe. The relative abundances of these isotopes can be determined using a mass spectrometer. In the mass spectrometer, the sample is first vaporised and then ionised.
   (ii) State what is meant by the term *isotopes*.
   (iii) Explain how, in a mass spectrometer, ions are detected and how their abundance is measured.
   (iv) Define the term *relative atomic mass* of an element.

(b) The relative abundances of the isotopes in this sample of iron were found to be as follows.

m/z	54	56	57
Relative abundance (%)	5.8	91.6	2.6

Use the data from the table to calculate the relative atomic mass of iron in this sample. Give your answer to one decimal place.

(c) Answer the following questions;
   (i) Give the electron arrangement of an Fe^{2+} ion.
   (ii) State why iron is placed in the d block of the Periodic Table.
   (iii) State the difference, if any, in the chemical properties of isotopes of the same element. Explain your answer.

2) (a) Answer the following questions
   (i) What are quantum numbers? What information are given by them?
   (ii) What do you understand by Photon? Write Planck's equation.

(b) Explain the following terms:
   (i) probability concept of electrons
   (ii) atomic orbital

(c) Define the following:
   (i) Afbau principle
   (ii) Hund's rule of maximum multiplicity
   (iii) Pauli's exclusion principle

1.1.1.2 Bonding

- Ionic Bonding (*Scope: types of chemical bonds, definition of electrovalent bond, definition of electrovalency, causes of variable electrovalency, general properties of ionic compounds*)
- Covalent bonding and dative covalent bonding (*Scope: definition of covalent bonds, Lewis concept, definition of covalency, causes of variable covalency, explanation of violation of octet rule with examples, characteristics of covalent compounds, comparison between the properties of electrovalent and covalent compounds, limitations of Lewis concept of covalent bond, definition of coordinate bond with some examples of coordinate molecules, properties of coordinate compounds*)
- Shapes of Molecules and Ions- Hybridisation of orbitals (*Scope: definition of hybridisation of orbitals, necessary conditions for hybridisation, types of hybridisation-sp, sp^2, sp^3*)
- Factors influencing shapes of molecules (*Scope: explanation of type of hybridisation, VSEPR theory, VBT and MOT*)
- Shapes of certain molecules (*Scope: explanation of shapes and bond angles in molecules and ions with up to six electron pairs surrounding central atom e.g. BF_3, CH_4, NH_4^+, SF_6, NH_3, H_2O, CO_2, etc. formula for predicting shapes of molecules and their bond angles for other molecules and ions*)

- Polar Molecules (*Scope: definition of electronegativity, polarity in covalent bonds, partial ionic character in covalent bond*)
- Dipole Moment (*Scope: definition of dipole moment, applications of dipole moment in determining the symmetry of the molecules, the polarity of the bonds and percentage of ionic character*)
- Partial Covalent Character in Ionic Compound (*Scope: explanation of partial covalent character in ionic compounds and Fajan's rule*)
- Hydrogen Bond (*Scope: definition of hydrogen bond, conditions required for the formation of hydrogen bond, types of hydrogen bond with examples, some consequences of hydrogen bonding*).
- Metallic Bonding (*Scope: explanation of metallic bond using electron-sea model, properties of metals based on electron-sea model*)
- *Van der Waal's forces* (*Scope: definition of Van der Waal's forces, causes of Van der Waal's forces, dipole-dipole interaction, ion-dipole interaction, London forces, factors determining Van der Waal's forces*)

Learning Experiences:

Ionic and Covalent Bond

The teacher may use SAMR model to deliver the lesson.

- The learner uses the simulation/video link (*https://www.youtube.com/watch?v=g-tE6MN-wrE&t=36s*) to explain electrovalency and covalency with reference to electrovalent bond and covalent bond.
- The learner creates 2D/3D model of a covalent and electrovalent molecules based on Lewis concept and shares the model to the class
- The learner explores the limitations of Lewis concept of covalent bond using relevant sources and shares to the class
- The learner designs experiments and carries out investigation to compare the properties of covalent, ionic and dative compounds.
- The learner explores the significance of ionic bond and covalent bond in daily life and presents to the class.
- The learner formulates a consumer product based on the knowledge properties of ionic and covalent compounds.
- The learner shares the formulation of the product to the class for feedback and comment.

Hybridisation and Shape of Molecules

The teacher may use Engage-Explore-Explain-Elaborate-Evaluate (5E model) to deliver the lesson. The teacher poses a question and makes the learners to engage on discussion.

Sample question: Why do different compounds have different shapes?

Engage

- The learner in team engages in discussing on the question posed by the teacher using simulations link (*https://phet.colorado.edu/sims/html/molecule-shapes/latest/molecule-shapes_en.html*).

Explore

- The learner in team explores hybridization of orbitals using relevant sources.

Explain

- The learner explains the hybridization using the analogy.
- The learner in team shares the analogy to the class for feedback and comment.

Elaborate

- The learner discusses the shape of molecules using the concept of hybridisation, VSEPR theory, VBT and MOT.
- The learner shares the discussion to the class for comment and feedback.
- The learner in team constructs 2D/3D structures of different molecules provided by the teacher using ChemDraw software or any other image editing software.
- The learner in team shares the work in Google Classroom or any other learning platform for assessment.

Evaluate

- The learner is assessed using assessment tools such as quiz, games, paper-pencil test, peer assessment, etc.

Extended Learning Activity

- The learner explores sp^3d and sp^3d^2 hybridization.

Polar Molecules

The teacher may use structured inquiry learning to deliver the lesson. The teacher provides a video tutorial (*https://youtu.be/ts-FuUp7b3c and https://youtu.be/uYCDhRzwQoY*) and worksheets on polar molecules. The worksheets contain the questions and procedures to solve numerical problems.

- The learner watches the video tutorial on polar molecules.
- The learner completes the worksheet on electronegativity, dipole moment, and the existence of partial covalent character in ionic compounds with reference to Fajan's rule.
- The learner submits the worksheet to the teacher for assessment.

Hydrogen Bond, Metallic Bond and Vander Waal's Force

The teacher may use Process Oriented Guided Inquiry Learning (POGIL) to deliver the lesson. The teacher provides the video tutorials (*https://www.youtube.com/watch?v=RSRiywp9v9w, https://www.youtube.com/watch?v=HGc9RFD7iSE, https://www.youtube.com/watch?v=S08qdOTd0w0*) and worksheets on hydrogen bond, metallic bond and Van der Waal's force. The worksheets contain detailed information, procedure, activities and questions on hydrogen bond, metallic bond and Van der Waal's force.

- The learner watches video tutorials on hydrogen bond, metallic bond and Van der Waal's forces.
- The learner in the team discusses hydrogen bonds and metallic bonds.
- The learner carries out the assigned task on the worksheet.
- The learner analyses the necessary conditions for formation of hydrogen bonds.
- The learner relates the significance of hydrogen bond in supporting different forms of life.
- The learner writes a report on historical evolution of metals, properties of metals and their applications with the changing time.
- The learner explains metallic bond in the light of the electron-sea model by using simulation.
- The learner applies the knowledge of properties of metals to design a metal roof for houses in the locality.
- The learner shares the design in the class or advertises on social media.
- The learner analyses the causes and the factors determining Van der Waal's forces.
- The learner compares the physical properties of molecules based on strength of Van der Waal's forces.

Assessment:

- The teacher may use assessment techniques such as question-answer, DARTs, games, crossword, puzzles, review, report writing etc. to assess the learner's conceptual understanding of chemical bonding.
- The teacher may assess the learner's skills in collaboration, computation, presentation, interpretation, investigation, information management, communication, differentiation, and creation while designing a metal roof and exploring the information on chemical bonding.
- The teacher may assess the learner's scientific values and attitudes such as curiosity, intellectual honesty, perseverance etc.
- The teacher may design assessment tools such as rubrics, checklist or rating scale in the worksheet to assess the learner and accordingly provide necessary intervention.
- For recording and reporting refer National School Curriculum Framework (NSCF-2021)

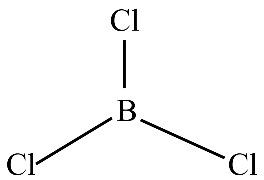
Resources:

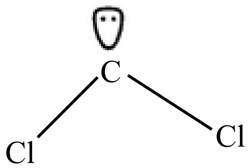
- REC Repository
- A Text Book of Chemistry Class XI (2015) - Macmillan publishers India Private Ltd.

- National School Curriculum Framework (NSCF-2021)
- Simulation link:
  https://phet.colorado.edu/sims/html/molecule-shapes/latest/molecule-shapes_en.html
- Video link:
  Chemical Bonding, Covalent Bond and Ionic Bonding
  https://www.youtube.com/watch?v=g-tE6MN-wrE&t=36s
  Hydrogen bond
  https://youtu.be/RSRiywp9v9w
  Vander Waal's forces
  https://www.youtube.com/watch?v=HGc9RFD7iSE,
  Metallic bonds
  https://www.youtube.com/watch?v=S08qdOTd0w0
  Polar and Non-polar molecules
  https://youtu.be/ts-FuUp7b3c
  The dipole moment of molecules
  https://youtu.be/uYCDhRzwQoY

Challenge Your Thinking

1. (a) The shape of the molecule BCl_3 and CCl_2 are shown below:



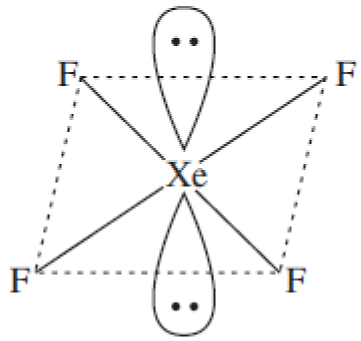


(i) Why is each bond angle 120^0 in BCl_3?

(ii) Predict the bond angle in CCl_2 and explain why this bond angle is different from that of BCl_3.

(b) Give the name of the molecule which has a bond angle of 109^0 28'. Give an example of one such molecule.

(c) The shape of XeF_4 molecule is shown below:



(i) State the bond angle in XeF_4

(ii) Suggest why the lone pairs of electrons are opposite to each other in the molecule.

(iii) Name the shape of this molecule, given that the shape describes the position of Xe and F atoms only.

2. (a) Explain the following:

(i) Oxygen and sulphur belong to the same group in the periodic table but their hydrides are in different physical states.

(ii) Hydrogen chloride is a polar covalent molecule whereas chlorine is a non-polar molecule.

(iii) Water has dipole moment but carbon dioxide does not.

(iv) Bonding molecular orbitals are more stable than antibonding molecular orbitals.

(b) What is the most significant difference between the valence bond approach to bonding and the molecular orbital approach to bonding?

(c) Which O_2^{2-} or O^{2-} exhibits paramagnetism?

(d) He_2 does not exist. Explain with reference to MOT.

1.1.2 Materials and Change

Material and change is one of most fascinating aspects of chemistry. Different materials react in different ways which sometimes lead to the formation of new substances. Heat, light, water and catalyst are some of the agents that can bring about the change in materials. Under material and change, learners study introduction to organic chemistry, hydrocarbons, alcohols and aromatic organic compounds.

Competencies:

- Apply the knowledge of organic compounds to understand the chemical reactions related to life and the crucial role that the organic compound plays in our daily life.

Objective(s):

Introduction to Organic Chemistry

i. Study the members of different classes of organic compounds to explain homologous series and functional group.
ii. Write structural formula of organic compounds and apply IUPAC rules to name them.
iii. Explain isomerism in organic compounds using relevant videos or simulation.
iv. Construct 2D/3D structures of different structural and stereo isomers of organic compounds.
v. Analyse the significance of structural and stereo isomers in the agrochemical and pharmaceutical industries.
vi. Investigate types of organic reactions such as substitution reaction, addition reaction, elimination reaction and rearrangement reaction with relevant examples.
vii. Explain the concept of nucleophiles and electrophiles using relevant video or simulation.
viii. Compare mechanism of free radical reaction and mechanism of polar reaction.
ix. Explain electron displacement effect with reference to inductive effect in organic compounds.
x. Differentiate between SN^1 and SN^2 and E^1 and E^2 reactions based on their reaction mechanisms.

Hydrocarbons

xi. Classify hydrocarbons based on structure.
xii. Construct general formula of alkanes, alkenes and alkynes based on their homologous series.
xiii. Compare 2D/3D molecular structures to explain different types of isomerism existing in alkanes, alkenes and alkynes.
xiv. Investigate the properties of alkanes, alkenes and alkynes to relate their properties to daily life.
xv. Design an experiment to demonstrate the laboratory preparation of acetylene.
xvi. Research on the extraction of hydrocarbons from local plants that may be used as fuel.
xvii. Apply the knowledge of hydrocarbon combustion to formulate a fuel that is eco-friendly.
xviii. Discuss / debate on the policies/resolutions adopted in national and international climate change conferences or summit such as COP26, UN conference on climate change, etc.
xix. Explain addition polymers with examples using relevant sources.
xx. Explain different terms associated with polymerisation and its classification using relevant sources.

xxi. Design space suits / fire fighter's gears / scuba diver's suit / bulletproof vest etc., using the knowledge of polymers.
xxii. Design a polymer that has a commercial value based on the knowledge of polymer and polymerization.
xxiii. Discuss the recent advancement in polymer science.

Alcohols

xxiv. Apply IUPAC rules to name alcohols.
xxv. Distinguish primary, secondary and tertiary alcohols
xxvi. Investigate the chemical properties of alcohol with relevant examples.
xxvii. Formulate a chemical combination for a particular brand of alcoholic beverage using the knowledge of properties of alcohol and quantitative and qualitative analysis.
xxviii. Critique on the national and international policies on use of alcohol related to youth, culture, environment, health and economy.

Aromatic Compounds

xxix. Construct 2D/3D model of benzene molecule to explain its structure using ChemDraw or any other image editing software.
xxx. Explain the general mechanism of electrophilic substitution reaction in benzene with relevant examples using illustration.
xxxi. Explain Friedel Craft's alkylation, acylation and effect of substituent on orientation and reactivity of benzene.
xxxii. Apply IUPAC rules to name benzene and its derivatives.
xxxiii. Design an experiment to explain the preparation of phenol.
xxxiv. Design an experiment to explain the reactions of phenol with dilute and concentrated nitric acids, and Kolbe's reaction.
xxxv. Relate the significance of benzene and phenol to health and medicine.
xxxvi. Write a report on the health risk associated with benzene and phenol.
xxxvii. Carry out qualitative analysis to identify aromatic compounds in some local plants that have commercial values.

1.1.2.1 Introduction to Organic Chemistry

- Functional Groups (*Scope: definition of functional group, names and structures of functional groups*)
- Homologous Series (*Scope: characteristics of homologous series*)
- Nomenclature of Different Classes of Organic Compounds (*Scope: types of nomenclature, common system, IUPAC rule, explanation and examples, General rules for naming organic compounds, nomenclature for branched chain alkanes, nomenclature for unsaturated hydrocarbons, nomenclature for compounds containing one functional group, multiple bonds and*

substituents, nomenclature for polyfunctional compounds , nomenclature for aromatic compounds, writing structural formulae from the IUPAC name of the compounds)

- Isomerism (*Scope: types of isomerism, structural isomerism: chain isomerism, position isomerism, functional isomerism, metamerism, tautomerism, Stereoisomerism: geometry and optical isomerism*)
- Types of Organic Reactions (*Scope: definition of substitution reaction, addition reaction, elimination reaction and rearrangement reaction with examples, nucleophiles and electrophiles: definition of nucleophilic reagents or nucleophiles, electrophilic reagents or electrophiles with examples, Mechanism of a free-radical reaction: Explanation of steps of free-radical mechanism using example of chlorination of alkane, Mechanism of a polar reaction: Explanation of steps of SN^1, SN^2, E^1 and E^2 reaction mechanism, Electron displacement effect (Inductive effect)*).

Learning Experiences:

Introduction to Organic Chemistry

The teacher may use Atkin and Karplus learning cycle (Explore - Concept Development -Application Cycle) to deliver the lesson. The teacher prepares worksheets on different classes of organic compounds and their functional groups along with the instruction.

Explore:

- The learner in team follows the instruction in the worksheets and identifies different classes of organic compounds and their functional groups.
- The learner completes the worksheets and submits to the teacher.

Concept development:

- The learner compares different organic compounds based on their structure to classify organic compounds.
- The learner compares the different members in the same series to define homologous series and functional group.

Concept application:

- The learner constructs molecular formula for higher homologues using the concept of homologous series.
- The learner names some commonly used organic compounds and identifies the functional group.
- The learner relates the significance of organic compounds and the functional groups to the biological system.

IUPAC Nomenclature of Organic Compounds

The teacher may use Process Oriented Guided Inquiry Learning (POGIL) to deliver the lesson. The teacher provides the worksheets on IUPAC nomenclature of organic compounds. The worksheets contain IUPAC rules for nomenclature, examples and practice questions.

- The learner follows the instructions and completes the worksheet.
- The learner submits the worksheet to the teacher for assessment.

Isomerism in Organic Compounds

The teacher may use Blended Learning to deliver the lesson.

- The learner explores different types of structural and stereoisomerism in organic compounds using relevant sources.
- The learner in team prepares PowerPoint presentation on different types of structural and stereoisomerism. The presentation includes simulations, videos and 3D structures of isomers drawn using ChemDraw or any other drawing tools.
- The learner in team presents the work to the class for feedback and comment.
- The learner in team analyses and discusses the significance of structural and stereoisomers in the agrochemical industries and other areas of life.
- The learner in team formulates the structural and stereoisomer that may be used in agrochemical and pharmaceutical industries.
- The learner advertises the formulation on social media.

Types of Organic Reaction

The teacher may use Cooperative Learning to deliver the lesson. The teacher prepares a video tutorial / shares a video tutorial on mechanism of free radical reaction and of polar reaction.

- The learner in team uses the simulation link/virtual lab / video link (*https://www.youtube.com/watch?v=Y0ZaVHiDqEk*) to explain substitution reaction, addition reaction, elimination reaction and rearrangement reaction with examples.
- The learner prepares a presentation on substitution reaction, addition reaction, elimination reaction and rearrangement reaction and present to the class.
- The learner uses the video link (*https://www.youtube.com/watch?v=R3PLq3dOqv4*) to explore the concept of nucleophiles and electrophiles.
- The learner prepares a PowerPoint presentation to explain nucleophiles and electrophiles and presents to the class for comment and feedback.
- The learner uses video tutorial prepared / shared by the teacher to explore the mechanism of free radical reaction and mechanism of polar reaction.
- After watching the video, the learner prepares a Power Point presentation to explain SN^1, SN^2, E^1 and E^2 with reference to the free radical reaction and mechanism of polar reaction.
- The learner in team explores and explains the electron displacement effect (inductive effect) in organic compounds.
- The learner presents the work to the class for feedback and comment.

Assessment:

- The teacher may use assessment techniques such as question-answer, DARTs, game, crossword puzzle, review, report writing etc. to assess the learner's conceptual understanding of introduction to organic chemistry.
- The teacher may assess the learner's skills in collaboration, presentation, interpretation, investigation, information management, communication, differentiation, and creation while formulating isomer, and exploring the information on introduction to organic chemistry.
- The teacher may assess the learner's scientific values and attitudes such as curiosity, intellectual honesty, perseverance etc.
- The teacher may design assessment tools such as checklist, rubric, or rating scale in worksheet to assess the learner and accordingly provide necessary intervention.
- For recording and reporting, refer National School Curriculum Framework (NSCF-2021)

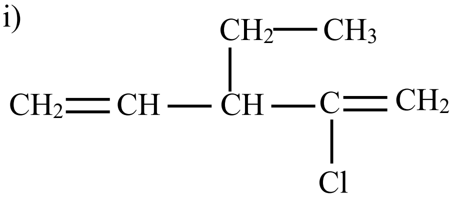
Resources:

- REC Repository
- A Text Book of Chemistry Class XI (2015) - Macmillan publishers India Private Ltd.
- National School Curriculum Framework (NSCF 2021)
- Video link:
- Organic Reactions
  https://www.youtube.com/watch?v=Y0ZaVHiDqEk o
- Nucleophiles and Electrophiles
  https://www.youtube.com/watch?v=R3PLq3dOqv4

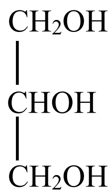
Challenge Your Thinking

1. a. Give the IUPAC name of the following:

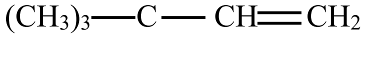
i)



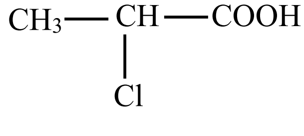
ii)



iii)



iv)



a. Write the structural formula of the following:

(i) 1- Chloropent-1-ene-4-yne

(ii) 4- ethyl – 2,2,6- trimethyl heptane
(iii) Ethane 1,2- dial
(iv) 5- methylhept-3-ene

b. What do you understand by SN^1 and SN^2 reactions? Taking suitable examples, discuss their mechanism.

c. What do you understand by elimination reaction? Discuss the mechanism of E_1 and E_2 reactions.

2. Answer the following questions with reference to isomerism.
   i. What characteristics are required in an organic compound for it to exhibit optical activity? Give an example.
   ii. Name four types of isomerism that a molecular formula C_4H_7Cl can give rise to. Represent he structures relevant to the isomerism.
   iii. What is keto -enol tautomerism? Explain with an example
   iv. Distinguish between tautomerism and metamerism.

1.1.2.2 Hydrocarbons

- Hydrocarbons (*Scope: classification of hydrocarbons into cyclic, acyclic, aliphatic and aromatic*).
- Alkanes (*Scope: structural isomerism in alkanes, preparations, physical and chemical properties (oxidation and halogenation), uses and impacts*).
- Alkenes (*Scope: isomerism in alkenes, cis- and trans-isomerism in relation to E and Z configuration, preparations, physical properties, chemical properties (electrophilic addition reactions with Br_2, H_2SO_4 and HCl with mechanism, use of Markownikoff's rule in prediction of products in addition reactions*), *uses and impacts*).
- Alkynes (*Scope: isomerism in alkynes, preparations, physical properties, chemical properties (electrophilic addition reaction with H_2, Br_2 and HCl with mechanism), uses and impacts*).
- Polymerisation (*Scope: classification: Condensation and Addition polymers: Preparation, properties, uses and impacts (Polyethene, PTFE, PVC, Polystyrene, Melamine and Bakelite)*).

Learning Experiences:

Alkane, Alkene and Alkyne

The teacher may use backward design to deliver the lesson.

Identify the desired goals

The learner is able to know or understand or do the following:

- Isomerism in hydrocarbons.
- Preparation of hydrocarbons.
- Investigate the properties and significance of hydrocarbons and relate their properties to daily life.

- Extraction of hydrocarbons from local plants that may be used as fuel.
- Analyze the impact of hydrocarbon as fuels.
- Formulate a fuel that is ecofriendly.

Determine acceptable evidence

- The learner is assessed on the above goals using various assessment technique and tools such as quiz, puzzles, games, question-answer, simulations, etc.

Plan learning experiences

- The learner explores the information on isomerism of hydrocarbons using the material provided by the teacher/ relevant sources.
- The learner uses the simulation/ video link (*https://www.youtube.com/watch?v=NgzFok_BA_0*) to explore isomerism in hydrocarbons.
- The learner in team explores the preparation of hydrocarbons and prepare PowerPoint presentation.
- The learner presents the work to the class for assessment.
- The learner explores the properties and significance of hydrocarbons and relates their properties to daily life.
- The learner writes the notes on the properties of hydrocarbons and submits to the teacher for feedback and comment.
- The learner carries out a research on extraction of hydrocarbons from local plants that may be used as fuel.
- The learner analyzes the impact of hydrocarbon as fuels.
- The learner formulates a fuel that is eco-friendly.
- The learner shares the formulation to the class for feedback and comment.
- The learner discusses /debates on the policies / resolutions adopted in national and international climate change conferences or summit such as COP26, UN conference on climate change, etc.

Polymers

Teacher may use Cooperative Learning strategy to deliver the lesson.

- The learner in team explores on classification of polymers (condensation and addition), preparation, properties and uses of polymers.
- The learner designs space suit / bulletproof vest / fire fighter's gears / scuba diver's suit / safety helmets, etc. using the knowledge of polymer.
- The learner in team prepares presentation and shares the work to the class for feedback and comment.

Significance and Impacts of Polymers

Teacher may use Problem Based Learning to deliver the lesson. The teacher helps the learners with resources and provides guidance.

Identify the problem

- The learner identifies the problem - The rising use of polymer may have impact on the environment.

Generate ideas to solve the problem

- The learner explores the preparation of Polyethene, PTFE, PVC, Polystyrene, Melamine, Bakelite and their uses.
- The learner works in team to research on alternative polymers that might have less impact on environment.

Action

- Considering the less environmental impact, the learner designs a model of alternative polymers that might have commercial values using the knowledge of hydrocarbon and polymerization.
- The learner advertises the model of the polymer in social media.

Evaluation

- The learner evaluates the model of the polymer based on feedback and comment.

Assessment:

- The teacher may use assessment techniques such as question-answer, DARTs, game, crossword puzzle, review, report writing etc. to assess the learner's conceptual understanding of hydrocarbons and polymers.
- The teacher may assess the learner's skills in collaboration, presentation, interpretation, investigation, information management, communicating skill, differentiation, and creation while designing polymer, and exploring the information on hydrocarbons and polymers.
- The teacher may assess the learner's scientific values and attitudes such as curiosity, intellectual honesty etc.
- The teacher may design assessment tools such as rubric, checklist or rating scale in worksheet to assess the learner and accordingly provide necessary intervention.
- For recording and reporting, refer National School Curriculum Framework (NSCF-2021)

Resources:

- REC Repository
- A Text Book of Chemistry Class XI (2015) - Macmillan publishers India Private Ltd.
- National School Curriculum Framework (NSCF-2021)
- video link:
- What are structures of isomers
  https://www.youtube.com/watch?v=NgzFok_BA_0

Challenge Your Thinking

1. (a) A mixture of methane and oxygen in the proportion of 1: 2 (by volume) can be exploded in a plastic bottle.

This experiment can be watched at https://youtu.be/xDlGSkTbh2A.
In this experiment, methane reacts violently with oxygen to form two products.

(i) Name the two products made in this reaction?

(ii) Complete the symbol equation for the reaction:

CH_4 + ………… → …………. + …………….

(iii) Explain why the bottle moves when the gases are ignited.

(iv) Methane is a saturated hydrocarbon. Explain saturated hydrocarbon.

(b) The torch used to start the modern Olympic Games uses a mixture of propane and butane. When propane and butane burn in air, they produce heat energy, and a flame.

(v) Name the two elements present in these compounds.

(vi) To which homologous series do propane and butane belong?

(vii) When do propane and butane produce toxic carbon monoxide?

2. Answer the following questions;

i. There are two types of polymerisation, addition and condensation. Explain the difference between these two types of polymerisation.

ii. Some plastics, formed by polymerisation, are non-biodegradable. Describe two pollution problems that are caused by non-biodegradable plastics.

iii. A condensation polymer can be made from the following monomers. $HOOC(CH_2)_4COOH$ and $H_2N(CH_2)6NH_2$. Draw the structural formula of this polymer.

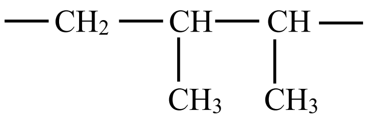
3. a. Synthetic polymers are disposed of in landfill sites and by burning.

i. Describe two problems caused by the disposal of synthetic polymers in landfill sites.

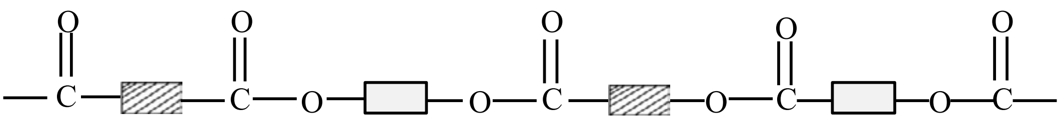
ii. Describe one problem caused by burning synthetic polymers.

iii. State two uses of synthetic polymers.

b. The structural formulae of two synthetic polymers are given below.



(Polymer A)



(Polymer B)

i. Draw the structural formula of the monomer of polymer A.

ii. Identify the functional group circled in polymer B.

iii. Deduce the two types of organic compound which have reacted to form polymer B.

iv. Explain the difference between addition and condensation polymers. Classify A and B as either addition or condensation polymers.

1.1.2.3 Alcohols

- Alcohols (*Scope: nomenclature of alcohols, primary, secondary and tertiary alcohols, structure of alcohols, oxidation of alcohols, dehydration of alcohol in the presence of acid catalyst, uses and implications of alcohol*).

Learning Experiences:

The teacher may use Guided Inquiry to deliver the lesson.

- The learner identifies and names some common products where alcohol is used.
- The learner classifies three types of alcohols based on the number of alkyl groups and hydroxyl groups.
- The learner names alcohols using IUPAC rules.
- The learner designs experiments and carries out investigation to demonstrate oxidation and dehydration of alcohol.
- The learner in team formulates a brand of alcoholic beverage using the knowledge of properties of alcohol.
- The learner shares the formulation to the class for feedback and comment.
- The learner in team discusses uses of alcohol and its close association in Bhutanese culture.
- The learner analyzes the use of alcohol to discuss the national and international policies related to youth, culture, environment, health and economy.
- The learner writes an analysis report and shares to the class for feedback and comment.

Assessment:

- The teacher may use assessment techniques such as question-answer, DARTs, game, crossword puzzle, review, report writing etc. to assess the learner's conceptual understanding of alcohol.
- The teacher may assess the learner's skills in collaboration, investigation, information management, communication, differentiation, and creation while designing an experiment, formulating an alcohol brand, and exploring the information on alcohol.
- The teacher may assess the learner's scientific values and attitudes such as curiosity, intellectual honesty etc.
- The teacher may design assessment tools such as rubric, checklist or rating scale in worksheet to assess the learner and accordingly provide necessary intervention.
- For recording and reporting, refer National School Curriculum Framework (NSCF-2021)

Resources:

- REC Repository
- A Text Book of Chemistry Class XI (2015) - Macmillan publishers India Private Ltd.
- National School Curriculum Framework (NSCF 2021)

Challenge Your Thinking

1. A certain organic liquid X neutral to litmus burn with a blue flame when a lighted tapper is applied to its surface. When a pellet of sodium is dropped into a test tube containing a little of X, it dissolves to give a compound A and a colorless gas B which burn with a slight explosion.

   On being dehydrated, liquid X gives a colourless gas C of empirical formula CH_2.

   The gas C reacts with Hydrogen to give a gas D of relative molecular mass 30 and with bromine vapour to give liquid E.

   When liquid X reacts with another liquid F in presence of small amount of conc. sulphuric acid and warmed, a sweet smelling vapour G is given off.

   Suggest the identity of substances X,A, B, C, D, E, F and G.

2. i. Discuss the impact of ethyl alcohol on health and economy.
   ii. What is denatured alcohol? How is it different from absolute alcohol.
   iii. What is the physiological action of alcohol?
   iv. What do labels 25^0 UP and 42.8 % V/V on 'Special Courier' whisky mean?

1.1.2.4 Aromatic Compounds

- Benzene (*Scope: structure and bonding: Kekule's structure, drawbacks of Kekule's structure, molecular orbital structure, evidence in support of molecular orbital structure, electrophilic substitution reaction of arenes, General mechanism of electrophilic substitution, reaction of arenes with concentrated nitric acid in the presence of sulphuric acid, reaction of arenes with a halogen, Friedel-Crafts alkylation and acylation, importance of Friedel-Crafts reaction in organic synthesis such as manufacture of polystyrene, effects of substituents on orientation and reactivity of benzene ,uses and implications*)
- Phenol (*Scope: nomenclature, structure, general methods of preparation, industrial preparation, , reactions with dilute and concentrated nitric acid, Kolbe's reaction ,uses and implications*)

Learning Experiences:

The teacher may use Kolb's Learning Cycle to deliver the lesson.

Concrete experience

- The learner identifies some commonly used consumer products that use benzene.
- The learner in team uses the simulation/video link (*https://www.youtube.com/watch?v=sYJkqX14BYY*) to explore and discuss the Kekule's structure, resonance hybrid and aromaticity of benzene.
- The learner in team constructs 2D/3D model of benzene molecule to explain its structure.
- The learner submits the model to the teacher for feedback and comments.

Reflective observation

- Based on the discussion, the learner draws the structure of benzene along with the explanation.
- The learner submits the work to the teacher for feedback and comment.
- The learner reviews the work and shares to the class.

Abstract conceptualization

- The learner explores nomenclature of benzene and its derivatives using the worksheet provided by the teacher.
- The learner uses simulation /video links (*https://youtu.be/I-7r-J_ABSI* and *https://www.youtube.com/watch?v=W3F03efrdzw*) to explain the general mechanism of electrophilic substitution reaction.
- The learner explains Friedel Craft's alkylation and acylation, using the mechanism of electrophilic substitution reaction.

Active experimentation

- The learner in team designs an experiment to explain the preparation and reactions of phenol with dilute and concentrated nitric acids, and Kolbe's reaction of phenol. *(Precaution: The reaction is explosive. Do not perform the reaction in the laboratory)*
- The learner shares the design to the class for feedback and comment.
- The learner relates the significance of benzene and phenol to health and medicine.
- The learner writes a report on the health risk associated with benzene and phenol.
- The learner submits the report to the teacher for feedback and comment.
- The learner in team carries out qualitative analysis to identify aromatic compounds in some local plants that have commercial values.
- The learner shares the findings to the class for feedback and comment.

Assessment:

- The teacher may use assessment techniques such as question-answer, DARTs, game, crossword puzzle, review, report writing etc. to assess the learner's conceptual understanding of aromatic compounds.
- The teacher may assess the learner's skills in collaboration, investigation, information management, communication, differentiation, and creation

while designing an experiment, and exploring the information on aromatic compounds.

- The teacher may assess the learner's scientific values and attitudes such as curiosity, intellectual honesty etc.
- The teacher may design assessment tools such as rubric, checklist or rating scale in worksheet to assess the learner and accordingly provide necessary intervention.
- For recording and reporting, refer National School Curriculum Framework (NSCF-2021)

Resources:

- REC Repository
- A Text Book of Chemistry Class XI (2015) - Macmillan publishers India Private Ltd.
- National School Curriculum Framework (NSCF-2021)
- Video links:
- Structure of Benzene
  https://www.youtube.com/watch?v=sYJkqX14BYY
- The basics of electrophilic substitution reaction
  https://www.youtube.com/watch?v=W3F03efrdzw
- The mechanism of electrophilic substitution reaction
  https://www.youtube.com/watch?v=I-7r-J_ABSI/

Challenge Your Thinking

1. B is a liquid and an aromatic compound with molecular weight 78 and burns with a sooty flame
   i. Give name of B
   ii. Write the molecular structure of B
   iii. Will B undergo addition reaction or substitution reaction?
   iv. What is the product formed when B is treated with conc. HNO_3 in presence of conc. H_2SO_4?

2. a. What is Friedel – Craft's reaction? Explain with an example.
   b. How is phenol prepared from chlorobenzene? Give all the reactions
   c. Phenol is acidic but aliphatic alcohol is neutral, though both are characterized by the presence of hydroxyl group. Explain
   d. What happens when phenol is treated with formaldehyde in presence of dilute acid or alkali?

1.1.3 Patterns in Chemistry

Pattern is a regular sequence that can be found in nature. Patterns in chemistry are observed in periodic trends in periodic table, pattern in types of chemical reactions and energy transfer. Under patterns in chemistry, learners study periodic table and chemical and phase equilibria.

Competencies:

- Apply the information of the periodic table in the field of material science to understand the properties of elements in designing products and processes.

  Objective(s):

  Periodic Table

  i. Classify elements as s-block, p-block, d-block and f-block elements using electronic configuration.
  ii. Predict the period, group and block for elements using mathematical formula.
  iii. Interpret the given mathematical data to analyse the variation of atomic radii, ionisation energy and electronegativity of elements in the periodic table.
  iv. Discuss the factors affecting ionisation energy of elements by using relevant sources.
  v. Justify the variation in melting and boiling points of elements in the second period and third period.
  vi. Explain the periodic properties of elements using online interactive periodic table.
  vii. Create an interactive periodic table by applying the knowledge of periodic properties of elements.
  viii. Predict the properties of elements that are yet to be discovered by applying the knowledge of periodic trends of elements and propose their position in the periodic table.
  ix. Formulate a nano-compound that may be used in the field of technology, industries and medicine.

- Use value of oxidation number to predict the reactivity of elements based on loss or gain of electrons by elements.

  Objective(s):

  Oxidation Number

  i. Calculate the oxidation number of elements, compounds and ions.
  ii. Design and carryout an experiment to identify reducing and oxidising agents.
  iii. Predict the feasibility of reaction based on redox reaction.
  iv. Explore the applications of redox reactions in daily life.

- Apply the knowledge and significance of chemical and phase equilibria in industries, living and non-living systems.

Objective(s):
Chemical Equilibria

i. Explain reversible reactions by designing the simulation / video.
ii. Explore examples and characteristics of physical changes in equilibrium by observing the natural phenomena in the surrounding.
iii. Demonstrate the features of chemical equilibrium by designing a simulation/video.
iv. Deduce mathematical expression for law of chemical equilibrium and equilibrium constant from law of mass action.
v. Solve numerical problems by applying the expression of equilibrium constant or law of equilibrium.
vi. Design and carryout an experiment to verify Le Chatelier's principle.
vii. Design a model of a chemical process for an industry to optimise the product and save time using the knowledge of chemical equilibrium.
viii. Analyse the biological significance of chemical equilibrium.

Phase Equilibria

ix. Determine the phase, components and degree of freedom of the system using Gibbs' phase rule.
x. Compare true equilibrium and metastable equilibrium with examples.
xi. Explain the phase diagram of the water system by constructing a model.
xii. Analyse the relationship between vapour pressure and boiling point of a substance.
xiii. Interpret Raoult's law to explain the lowering of vapour pressure due to the presence of non-volatile solute.
xiv. Construct a model of a cooking system for domestic use based on the principles of Raoult's law.
xv. Design an experiment to investigate the properties of ideal and non-ideal solutions.
xvi. Interpret graphs to explain positive and negative deviations from an ideal solution in terms of intermolecular forces.
xvii. Construct vapour pressure and composition curves based on the concept of Raoult's law and Dalton's law of partial pressures.
xviii. Design and carry out an experiment to investigate the properties of azeotropes.
xix. Relate the knowledge of vapour pressure and boiling point to explain fractional distillation.
xx. Apply the knowledge of fractional distillation to construct a physical model of fractionating column that may be used in the industries.

1.1.3.1 Periodic Table

- Classification of Elements (*Scope: classification of elements as s, p, d and f block elements, prediction of period, group and block for elements based on electronic configuration*)
- Periodic Properties (*Scope: atomic radius: covalent radius, Van der Waals' radius, metallic radius, Variation of atomic radii, comparison of the ionic and atomic radii, Ionization enthalpy: definition of first ionisation energy and successive ionisation energies, variation of ionisation energy in the periodic table, factors on which ionisation energy depends, electronegativity: variation of electronegativity in period and group, melting point and boiling point: trends in melting and boiling points of elements in the second period and third period*)

Learning Experiences:

The teacher may use Substitution, Augmentation, Modification, Redefinition (SAMR) model to deliver the lesson.

- The learner explores the periodic properties of elements using online interactive periodic table (*https://ptable.com/#Properties*)
- The learner writes electronic configuration for the elements using the given link and groups them into s, p, d and f block elements.
- The learner predicts the period, group and block of elements using the mathematical formula.
- The learner interprets the mathematical data from the link to analyse the variation of atomic radii, ionisation energy and electronegativity of elements in the periodic table.
- The learner submits the work to the teacher for assessment.
- The learner in team discusses the factors affecting ionisation energy of elements.
- The learner justifies the variation in melting and boiling points of elements in the second period and third period and shares the work to the class.
- The learner predicts the properties of elements that may be discovered by applying the knowledge of periodic trends of elements and propose their positions in the periodic table.
- The learner creates an interactive periodic table by applying the knowledge of periodic table using programming language and shares to the class / Google Classroom for feedback and comment.
- The learner studies the uses and implications of elements and formulates a nano-compound that may be used in the field of technology, industries and medicine.
- The learner shares the formulation to the class for feedback and comment.

Assessment:

- The teacher may use assessment techniques such as question-answer, DARTs, game, crossword puzzle, review, report writing etc. to assess the learner's conceptual understanding of periodic table.

- The teacher may assess the learner's skills in collaboration, computation, interpretation, information management, communication, differentiation, and creation while designing an interactive periodic table, and exploring the information on periodic table.
- The teacher may assess the learner's scientific values and attitudes such as curiosity, intellectual honesty etc.
- The teacher may design assessment tools such as rubric, checklist or rating scale in worksheet to assess the learner and accordingly provide necessary intervention.
- For recording and reporting, refer National School Curriculum Framework (NSCF-2021)

Resources:

- REC Repository
- A Text Book of Chemistry Class XI (2015) - Macmillan publishers India Private Ltd.
- National School Curriculum Framework (NSCF-2021)
- Link:
- Interactive periodic table

  https://ptable.com/#Properties

Challenge Your Thinking

1. (a)The table given below shows the mass number and the number of neutrons in four elements A, B, C and D.

Element	A	B	C	D
Mass number	23	20	12	35
Neutrons in the nucleus	12	10	6	18

Refer the table and answer the following questions.

(i) Write down the atomic number of element D.

(ii) The electron configuration of element A is $1s^2$, $2s^2$, $2p^6$, $3s^2$. In the same way write the electron configuration of element D.

(iii) What will be the nature of compounds formed by A and D?

(b) The atoms X and Y have the electron configurations as follows:

X: 1s2, 2s2, $2p^6$, $3s^2$, $3p^6$, $3d^{10}$, $4s^2$

Y: $1s^2$, $2s^2$, $2p^6$

(i) Mention the period and the group to which X and Y belong.

(ii) Write down the formla of the compound formed by X and Y.

2. (a) Arrange the elements with atomic number 17, 18 and 19 in order of increasing ionisation potential.

(b) Explain why

i. size of atom decreases across the period.
ii. second ionisation energy of an element is greater than its first ionisation energy.
iii. Electron affinity decreases down the group.

1.1.3.2 Oxidation Number

- Redox Reactions and Oxidation Number (*Scope: electronic concept of oxidation and reduction: explanation of electronic concept of oxidation and reduction, Redox reactions: explanation of redox reactions with examples, definition of oxidising agent and reducing agent based on electronic concept, identification of oxidising and reducing agents in redox reactions, rules for oxidation number: definition of oxidation number, rules for assigning oxidation numbers to atoms in elements, compounds and ions, oxidation number and nomenclature, definition of oxidation and reduction in terms of oxidation number and applications*).

Learning Experiences:

The teacher may use Inquiry Based Learning and Claim-Evidence-Reasoning (CER) to deliver the lesson.

- The learner in team designs and investigates redox reaction using iron nail and copper sulphate solution.
- The learner predicts oxidizing and reducing agents and calculates the oxidation number for iron and copper.
- The learner writes redox reaction for iron and copper based on oxidation number.
- The learner shares the work to the class.

Claim: Does iron rust more quickly in moist or dry air?

- The learner identifies the real life examples and applications of redox reactions.
- The learner explores the chemistry of redox reactions and explains redox reaction.
- The learner formulates the hypothesis based on the claim.

Evidence:

- The learner designs and carry out an experiment to test the hypothesis.

Reasoning:

- The learner justifies the findings based on the concept of redox reaction.
- The learner prepares the PowerPoint presentation on redox reaction and presents to the class.

Extended Learning Activity

- Vitamin C is antioxidant and may help prevent cancer in people. The learner carries out a research to find out more information on anti-carcinogenic property of vitamin C.

Assessment:

- The teacher may use assessment techniques such as question-answer, DARTs, game, crossword puzzle, review, report writing etc. to assess the learner's conceptual understanding of oxidation number.
- The teacher may assess the learner's skills in collaboration, computation, and interpretation, information management, investigation, analysis, communication, differentiation, and creation while designing and carrying out an experiment, and exploring the information on oxidation number.
- The teacher may assess the learner's scientific values and attitudes such as curiosity, intellectual honesty etc.
- The teacher may design assessment tools such as rubric, checklist or rating scale in worksheet to assess the learner and accordingly provide necessary intervention.
- For recording and reporting, refer National School Curriculum Framework (NSCF-2021)

Resources:

- REC Repository
- A Text Book of Chemistry Class XI (2015) - Macmillan publishers India Private Ltd.
- National School Curriculum Framework (NSCF-2021)

Challenge Your Thinking

1. (a) For the following balanced redox reaction answer the following questions

$$2Fe^{+2}(aq) + H_2O_2(aq) \rightarrow 2Fe^{+2}(aq) + 2\ OH^{-1}(aq)$$

(i) What is the oxidation state of oxygen in H_2O_2 ?
(ii) What is the element that is oxidized?
(iii) What is the element that is reduced?
(iv) What is the oxidizing agent?
(v) What is the reducing agent?
(vi) How many electrons are transferred in the reaction as it is balanced?

(2) Determine the oxidation number of each atom in the following substances

(i) NF_3 N__________ F__________

(ii) K_2CO_3 K__________ C__________ O__________

(iii) NO_3^- N__________ O__________

(iv) HIO_4 H__________ I__________ O__________

1.1.3.3 Chemical Equilibria

- Concept and Laws of Chemical Equilibrium (*Scope: reversible reactions, explanation of reversible reactions with examples, equilibria involving physical changes: examples of physical changes in equilibrium, general characteristics of equilibria involving physical processes, Equilibria in chemical process: dynamic equilibrium: explanation of dynamic nature of chemical reaction in equilibrium, concept of chemical equilibrium: explanation of concept of chemical equilibrium using graph and examples, main features of chemical equilibrium, Law of chemical equilibrium from law of mass action: deduction of expression for law of chemical equilibrium from law of mass action, deduction of expressions for equilibrium constant ‘K_C’ and ‘Kp’ for homogenous and heterogeneous reactions, relation between K_C and Kp, units and calculations of K_C and Kp, Le Chatelier’s principle: effects of change in concentration, pressure and temperature on the position of equilibrium in homogeneous reactions and applications*).

Learning Experiences:

Reversible and Irreversible Reactions

The teacher may use Collaborative Learning to deliver the lesson.

- The learner in team uses the video link (*https://www.youtube.com/watch?v=br8lKynV1Hc*) to explore and differentiate reversible and irreversible reactions.
- The learner in team designs a simulation/video and prepares a PowerPoint presentation to explain reversible and irreversible reactions to the class.
- The learner in team presents the work to the class for feedback and comment.
- The learner explores physical processes in nature to identify the characteristics of equilibria.
- The learner designs an experiment and demonstrates a state of equilibrium in one of the physical processes.
- The learner in team explains chemical equilibrium using an analogy (*https://www.youtube.com/watch?v=_QnRt7PYzeY*).

Law of Chemical Equilibrium

The teacher may use computational thinking to deliver the lesson.

- The learner explores the law of mass action using the video link (*https://www.youtube.com/watch?v=2hwfBIelucA*).
- The learner deduces mathematical expression for law of chemical equilibrium and equilibrium constant from law of mass action.
- The learner solves numerical problems by applying the law of chemical equilibrium.
- The learner submits the work to the teacher for assessment.
- The learner designs and carries out an experiment to verify Le Chatelier’s principle.

- The learner in team discusses the biological significance of chemical equilibrium.
- The learner shares the significance to the class for feedback and comment.
- The learner designs a model of a chemical process for an industry to optimise the product and save time using the knowledge of chemical equilibrium.
- The learner shares the design to the class for feedback and comment.

Assessment:

- The teacher may use assessment techniques such as question-answer, DARTs, game, crossword puzzle, review, report writing etc. to assess the learner's conceptual understanding of chemical equilibria.
- The teacher may assess the learner's skills in collaboration, computation, information management, analysis, communication, differentiation, and creation while designing experiment, chemical model and simulation, and exploring the information on chemical equilibria.
- The teacher may assess the learner's scientific values and attitudes such as curiosity, intellectual honesty etc.
- The teacher may design assessment tools such as rubric, checklist or rating scale in worksheet to assess the learner and accordingly provide necessary intervention.
- For recording and reporting, refer National School Curriculum Framework (NSCF-2021)

Resources:

- REC Repository
- A Text Book of Chemistry Class XI (2015) - Macmillan publishers India Private Ltd.
- National School Curriculum Framework (NSCF-2021)
- video link:
  What are reversible reaction
  https://www.youtube.com/watch?v=br8lKynV1Hc o
  Chemical Equilibrium
  https://www.youtube.com/watch?v=_QnRt7PYzeY o
  The Law of mass action
  https://www.youtube.com/watch?v=2hwfBIelucA

Challenge Your Thinking

1. (a) What is meant by reversible and irreversible reactions? Explain with suitable examples.

   (b) In manufacture of ammonia, the reaction. Is denoted by the following:

   $$N_2 + 3H_2 \rightleftharpoons 2NH_3 , \quad \Delta H = + x \text{ k.cal}$$

Apply Le Chatelier's principle to this reaction and predict what is the effect of increasing the

(i) Temperature
(ii) Pressure
(iii) Volume of hydrogen

(c) Discuss the significance of the equilibrium constant Kc for reversible reactions.

2. (a) What is Le Chatelier's principle? Discuss its application to the following equilibria

(i) $2SO_2 + O_2 \rightleftharpoons 2SO_3$ + xcal

(ii) $2HI \rightleftharpoons$ H. + I_2 + -xcal

(b) State and explain the law of mass action.

1.1.3.4 Phase Equilibria

- Phase and Phase Diagram (*Scope: explanation of the terms phase, components and degree of freedom with examples, equilibrium: definition of true equilibrium and metastable equilibrium with examples, phase diagram: explanation of phase diagram, definition and representation of invariant system, univariant system and bivariant system in phase diagram, phase diagram of water system: interpretation of phase diagram of water system*)
- Vapour Pressure, Law of Vapour Pressure and Law of Partial Pressure. (*Scope: vapour pressure of a liquid: definition of vapour pressure of liquid, Raoult's law: statements and expressions of Raoult's law for dilute solutions of non-volatile solutes, expression for relative lowering of vapour pressure, numerical problems, Dalton's law of partial pressure: statement and expression of Dalton's law of partial pressure*)
- Ideal and Non-ideal Solutions (*Scope: explanation of ideal and non-ideal solutions using vapour pressure-composition curves, explanation of negative and positive deviations from ideal solution, Azeotropes: definition of azeotropes, explanation of types of azeotropes with examples, fractional distillation: explanation of principle of fractional distillation for ideal solution*) *and applications.*

Learning Experiences:

Phase Equilibria

The teacher may use CER to deliver the lesson.

Claim:

Question: If you heat a beaker of ice until it is boiling, will the temperature change constantly or remains constant for certain period of time?

Evidence:

- The learner follows the instruction and carries out the experiment to explain system, surrounding, phase, component and degree of freedom. (*Refer appendix 11(b and c) for sample*).
- The learner records the data from the experiment.
- The learner constructs a phase diagram of water system using the data.

Reasoning:

- The learner answers the questions based on the experiment.
- The learner compares true equilibrium and metastable equilibrium using examples.
- The learner explains the phase diagram of the water system.
- The learner analyses the relationship between vapour pressure and boiling point of water.

Raoult's Law

The teacher may use Build Your Model strategy to deliver the lesson.

- The learner designs a model to explain Raoult's law.
- The learner interprets Raoult's law to explain the lowering of vapour pressure due to the presence of volatile and non-volatile solutes.
- The learner plots and interprets the graph based on the data provided by the teacher.
- The learner solves numerical problems on Raoult's law.
- The learner constructs a model of a cooking system for domestic use based on the principles of Raoult's law.
- The learner shares the model to the class for feedback and comment.

Ideal and Non-ideal Solutions

The teacher may use Scientific Inquiry to deliver the lesson.

- The learner explores the information on ideal and non-ideal solution using relevant sources.
- Based on the information, the learner designs an experiment to investigate the properties of ideal and non-ideal solutions. *(Refer Appendix 11(d) for sample)*
- Based on the design, the learner carries out the investigation and records the data.
- Using the data, the learner plots and interprets the graphs to explain positive and negative deviations from an ideal solution.
- The learner designs a model to explain Dalton's law of partial pressure.
- The learner constructs vapour pressure and composition curves based on the concept of Raoult's law and Dalton's law of partial pressures.
- The learner uses the video link (*https://www.youtube.com/watch?v=DIbuD6-ieqs&t=166s*) to study the properties of azeotropes.

- Based on the information, the learner designs an experiment to investigate the properties of azeotropes.
- The learner relates the knowledge of vapour pressure and boiling point to explain fractional distillation.
- The learner applies the knowledge of fractional distillation to construct a physical model of fractionating column that may be used in the industries.

Assessment:

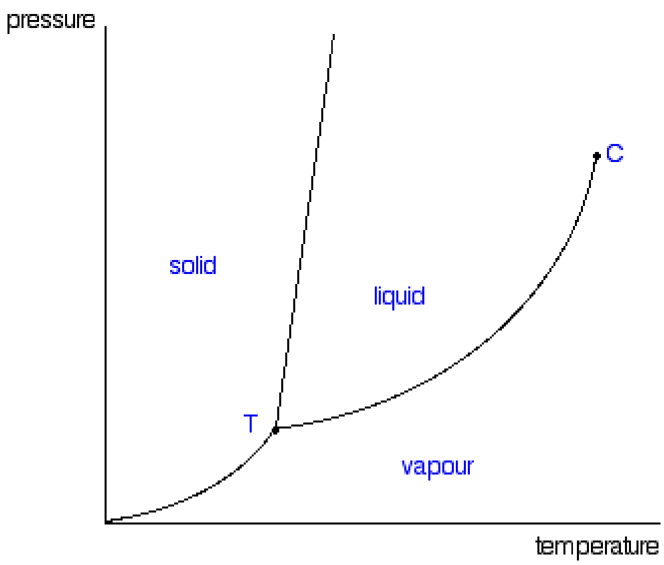
- The teacher may use assessment techniques such as question-answer, DARTs, game, crossword puzzle, review, report writing etc. to assess the learner's conceptual understanding of phase equilibria.
- The teacher may assess the learner's skills in collaboration, computation, information management, analysis, communication, investigation, differentiation, and creation while designing experiment and model, and exploring the information on phase equilibria.
- The teacher may assess the learner's scientific values and attitudes such as curiosity, intellectual honesty etc.
- The teacher may design assessment tools such as rubric, checklist or rating scale in worksheet to assess the learner and accordingly provide necessary intervention.
- For recording and reporting, refer National School Curriculum Framework (NSCF-2021)

Resources:

- REC Repository
- A Text Book of Chemistry Class XI (2015) - Macmillan publishers India Private Ltd.
- National School Curriculum Framework (NSCF-2021)
- video link:
  What is an Azeotrope?
  https://www.youtube.com/watch?v=DIbuD6-ieqs&t=166s

Challenge Your Thinking

1. The diagram below shows the phase diagram for water – water vapour system. Answer the questions that follow.



   (i) What do the curves TC, TD, and TA represent?
   (ii) What is the name given to the point T. What does it represent?
   (iii) How many phases are represented in the diagram?

2. (a) Two liquids A (bp 85^0 C) and B (bp 100^0 C) form a mixture which shows a minimum in its vapour pressure composition curve.
   i. Schematically represent the temperature- composition curves for the vapours in equilibrium with the liquids.
   ii. Can the two liquids be completely separated?
   iii. What is an azeotropic mixture?

   (b) Define Raoult's law. Mention the two limitations of the law.

1.2 Curriculum Content (Class XII)

1.2.1 Classifying Materials

Classifying materials is grouping materials based on their similar properties. Materials are classified in order to study their properties and identify common patterns among them. Under classifying materials, learners study acid-base equilibria, redox equilibria, nuclear chemistry, chemical kinetics, and thermodynamics.

Competencies:

- Apply the concept of ionic equilibria in relation to industries, environment, agriculture, food products and human health.

  Objective(s):

  Acid-base Equilibria

  i. Explain ionic equilibrium and dissociation of electrolytes using simulation.

ii. Deduce the mathematical expression for degree of dissociation.
iii. Explore factors that affect the degree of dissociation.
iv. Derive the mathematical expression for Ostwald's dilution law to draw the relationship between degree of dissociation and concentration of solution for weak electrolytes.
v. Solve numerical problems based on Ostwald's dilution law.
iv. Interpret different values of K_a and K_b of acids and bases to predict their strength.
v. Solve numerical problems based on K_a and K_b using relevant mathematical expression and data.
vi. Explore Bronsted-Lowry concept of acid and base from relevant sources.
vii. Draw illustrations of chemical equations to explain conjugate acid-base pairs.
viii. Convert mathematical expression of ionic product of water (K_w) into a statement.
ix. Derive the mathematical expression for pH and pOH from their statements.
x. Use mathematical expressions and the data to solve numerical problems based on pH and pOH.
xi. Demonstrate the body's natural buffer system using acid and base.
xii. Apply the knowledge of volumetric analysis and neutralisation reaction to design an experiment to compare the effectiveness of two or more samples of antacids.
xiii. Explore the characteristics of pH indicators to predict their suitability for different types of acid base titrations.
xiv. Design an experiment to investigate buffer action of buffer solutions.
xv. Apply the knowledge of buffers to formulate different combinations of chemicals for preparing a buffer, which may be used as a dialysis solution.
xvi. Analyse the importance of acid, base, and buffer in relation to environment, agriculture, human health and food industries.

Redox Equilibria

xvii. Explain electrode potential and different parts of an electrochemical cell after exploring from relevant sources.
xviii. Explore the working of the electrochemical cell by designing a galvanic cell which can provide energy to run a wall clock, light LED bulb, etc.
xix. Represent oxidation half-cell, reduction half-cell and net cell reaction for the galvanic cell.

xx. Conduct an experiment to investigate factors affecting the electrode potential.

xxi. Explain the construction and working of SHE as a reference electrode by using simulation/video.

xxii. Calculate e.m.f of a galvanic cell at standard conditions using mathematical expression and the data.

xxiii. Compare the e.m.f. values of metals in electrochemical series to design a container that may be used to store metal salt solutions in the laboratory.

xxiv. Apply Nernst equation in relation to the standard e.m.f. value to calculate the e.m.f. of galvanic cell at non-standard conditions.

xxv. Evaluate use of electrochemical cell in an electric car in terms of energy efficiency, renewability and environmental impact.

- Relate the knowledge of Nuclear Chemistry to evaluate the application and impact of nuclear materials with reference to medicine, defence, engineering and source of energy.

Objective(s):

Nuclear Chemistry

i. Write the historical narratives of the discovery of radioactive substances, their uses and impact on health, environment and international politics.

ii. Explore the properties of radioactive rays.

iii. Interpret the stability of different elements using serge chart.

iv. Explain modes of radioactive decay by using nuclear equations.

v. Apply the knowledge of modes of decay to state group displacement law.

vi. Explain nuclear transmutation using simulation, video, etc.

vii. Solve numerical problems based on half-life of radioactive elements.

viii. Evaluate the significance of radioactive substances with reference to energy source, medicine, research, agriculture, environment and politics.

ix. Argue for and against the use of nuclear weapons in the world.

- Apply the knowledge of chemical kinetics to evaluate its significance in the field of industry, cosmology, geology, biology, engineering etc.

Objective(s):

Chemical Kinetics

i. Investigate the rate of reaction in relation to rate equation and rate constant by using simulation.

ii. Explore characteristics of rate constant.

iii. Explain collision theory.

iv. Design and carry out an experiment to investigate the factors affecting the rate of reaction.

v. Classify reactions based on molecularity.

vi. Apply the knowledge of the factors affecting the rate of reaction to design chemical processes for industry to save time and optimize product.

vi. Explore zero, first and second order of reaction and the units of rate constant using graphs and relevant mathematical data.

vii. Explain the rate determining step in a multi-step chemical reaction by using analogy.

viii. Determine the order of reaction and rate constant by using the mathematical expression and experimental data.

ix. Carry out Chemistry project based on chemical kinetics.

- Relate the concept of thermodynamics to heat, work and interconversion of energy in understanding the physical and chemical processes taking place in the universe.

  Objective(s):

  Thermodynamics

  i. Explain open, closed and isolated systems by using relevant devices.

  ii. Compare intensive and extensive properties of a system using analogy.

  iii. Explain reversible, irreversible and thermodynamic processes using simulation, videos, analogy etc.

  iv. Derive the equation for change in internal energy.

  v. Calculate heat and work done of a system using mathematical expression and the given data.

  vi. Convert the statement of the first law of thermodynamics into mathematical expression.

  vii. Explore the limitations of the first law of thermodynamics.

  viii. Design an experiment to investigate enthalpy change in a chemical reaction.

  ix. Establish the relationship between enthalpy and internal energy using relevant mathematical expression.

  x. Calculate enthalpy and internal energy for chemical reactions using mathematical expression and the data.

  xi. Explore different physical and chemical processes in the surrounding to identify spontaneous and non-spontaneous processes.

  xii. Explore the statements of the second law of thermodynamics.

  xiii. Explain entropy in relation to its significance in nature by using simulation or video.

  xiv. Solve numerical problems using the expression of Gibb's free energy.

  xv. Design a fast defroster using the principles of thermodynamics that can be used in the kitchen.

1.2.1.1 Acid-base Equilibria

- Ionic Equilibria and Degree of Dissociation (Scope: *dissociation of electrolytes in aqueous solution, degree of dissociation: definition, factors, derivation and statement of Ostwald's dilution law, calculations*).
- Acid-base Concept and Strength of Acid and Base (Scope: *acid-base concept: Bronsted-Lowry concept of acid and base: explanation of conjugate acid-base pairs with examples: Lewis concept of acids and bases: explanation of Lewis concept with examples, strength of acid and base: ionisation constant of acid 'K_a' and base 'K_b', significance of K_a and K_b, calculations*).
- Ionic Product of Water (Scope: *pH, pOH, expression and numerical problems, pH indicators*).
- Neutralization and Buffer solution (Scope: s*trong acid vs. strong base, weak acid vs. strong base, strong acid vs. weak base, weak acid vs. weak base, Buffer solution: preparation of buffer solution, types of buffer solution, buffer action, applications of buffer*).

Learning Experiences:

Ionic Equilibria and Degree of Dissociation

The teacher may use Atkin and Karplus learning cycle to deliver the lesson.

Exploration

- The learner uses PhET simulation link *https://phet.colorado.edu/sims/html/acid-base-solutions/latest/acid-base-solutions_en.html* to explore ionic equilibrium and dissociation of electrolytes.

Concept development

- The learner differentiates between strong electrolyte and weak electrolyte.
- The learner deduces the mathematical expression of degree of dissociation for weak electrolyte.
- The learner explores factors that affect the degree of dissociation.
- The learner derives the mathematical expression for Ostwald's dilution law and submits the work to the teacher for feedback and comment.
- The learner solves numerical problems based on Ostwald's dilution law and submits to the teacher for feedback and comment.

Concept application

- The learner analyses the biological significance of weak electrolyte in relation to Ostwald's dilution law.

Acid- Base Concept and, Strength of Acid and Base

The teacher may use Atkin and Karplus learning cycle to deliver the lesson.

Exploration

- The learner explores Bronsted-Lowry concept of acid and base from relevant sources.

Concept development

- The learner draws illustrations of chemical equations to explain conjugate acid-base pairs.
- The learner presents the illustrations to the class for feedback and comment.
- The learner writes the expression for K_a and K_b.
- The learner interprets different values of K_a and K_b of acids and bases to predict their strength.
- The learner solves numerical problems based on K_a and K_b.
- The learner submits the work to the teacher for feedback and comment.

Concept application

- The learner identifies the strength of acids and bases based on the values of K_a and K_b.

Ionic Product of Water

Contact:

The teacher may use Atkin and Karplus learning cycle to deliver the lesson.

Exploration

- The learner in team discusses ionic product of water.

Concept development

- The learner converts mathematical expression of ionic product of water (K_w) into a statement.
- The learner derives the mathematical expression for pH and pOH from their statements.
- The learner uses mathematical expressions and the data to solve numerical problems based on pH and pOH.
- The learner submits the work to the teacher for feedback and comment.

Concept application

- The learner analyses the significance of pH and pOH in biological system.
- The learner shares the analysis to the class.

Neutralization and Buffer Solution

The teacher may use Blended Learning (BL) to deliver the lesson. The teacher uploads the materials on Google Classroom two or three days before the lesson.

- The learner uses the uploaded materials to study the characteristics of pH indicators to predict their suitability for different types of acid base titrations.
- The learner applies the knowledge of volumetric analysis and neutralisation reaction to design an experiment and carries out the

investigation to compare the effectiveness of two or more brands of antacids.

- The learner shares the findings of the investigation to the class.
- The learner in team discusses buffer, types of buffer and buffer action.
- The learner in team designs an experiment to investigate buffer action of buffer solutions to explain natural buffer system in blood.
- The learner shares the design to the class.
- The learner formulates a buffer solution, which may be used as a dialysis solution.
- The learner shares the formulation to the class.

Assessment:

- The teacher may use assessment techniques such as question answer, DARTs, game, crossword puzzle, review, report writing, etc. to assess the learner's conceptual understanding of ionic equilibria, degree of dissociation, acid-base concept, and ionic product of water, neutralization and buffer.
- The teacher may assess the learner's skills in collaboration, presentation, interpretation, investigation, information management, communication, differentiation, analysis and creation while designing experiment and exploring information on ionic equilibria.
- The teacher may design assessment tools such as rubric or checklist or rating scale in worksheet to assess the learner and accordingly provide necessary intervention.
- For recording and reporting, refer National School Curriculum Framework (NSCF-2021).

Resources:

- REC repository
- National School Curriculum Framework 2021
- Textbook of chemistry Class XII (2017) S.Chand Publisher.

  https://phet.colorado.edu/sims/html/acid-base-solutions/latest/acid-base-solutions_en.html

Challenge Your Thinking

1. At 25°C, the value for K_W is 1.00×10^{-14} Use this information to answer the following questions
   i. Show why the pH of pure water is 7 at this temperature.
   ii. At 30°C, K_W has a value of 1.471×10^{-14} (in the same units). Calculate the pH of pure water at this temperature.
   iii. As the temperature increases, the value of KW increases. Use your knowledge of Le Chatelier's principle to work out whether the ionization of water is exothermic or endothermic:

$$2H_2O \rightleftharpoons H_3O + OH^-$$

2. A student formulates a buffer that may be used in dialysis solution. The pH of dialysis solution must be equal to the pH of body fluids.
    i. Name the buffer that may be used in dialysis solution
    ii. Why should dialysis solution have pH equal to pH of body fluids?
    iii. Explain the mechanism of buffer action
    iv. Define buffer

1.2.1.2 Redox Equilibria

- Electrochemical Cell (Scope: *construction of Daniel cell, flow of electrons and mechanism of current production, oxidation half-cell reaction, reduction half-cell reaction, net cell reaction, types of electrode potential, factors affecting electrode potential*, *uses, impact on health and environment*).
- Electrochemical Series and e.m.f. of the Cell (Scope: *application of electrochemical series, construction of standard hydrogen electrode SHE/NHE, measurement of standard electrode potential using SHE, calculation of e.m.f. of a galvanic cell under standard conditions, calculation of e.m.f. of a galvanic cell under non-standard condition using Nernst equation, application of electrochemical cells in general*).

Learning Experiences:

Electrochemical Cell

The teacher may use 5E model to deliver the lesson.
Question: How is electricity produced in a cell/battery?

Engage

- The learner looks at different types of cell/battery and identifies the materials used in the cell or battery.
- The learner in team explores the information on different parts of an electrochemical cell, cell notation and electrode potential.

Explore

- The learner explores the information on how chemical energy is converted into electrical energy.
- Based on the information, the learner constructs an electrochemical cell and demonstrates the working of the cell.

Explain

- The learner in team explains the working of the electrochemical cell.
- The learner writes oxidation half-cell, reduction half-cell and net cell reaction for the galvanic cell constructed.
- Based on the working of electrochemical cell, the learner designs a simulation/video to explain the flow of electric current and electrons in the cell.
- The learner presents the simulation/video to the class.

Elaborate

- The learner in team conducts an experiment to investigate factors affecting the electrode potential.
- The learner in team shares the findings of the experiment to the class for feedback and comment.
- The learner designs a galvanic cell, which can provide energy to run a wall, clock, light LED bulb etc.

Evaluate

- The learner is assessed through question-answer, quiz, games, puzzles, etc. for feedback and comment.

Electrochemical Series

The teacher may use Inductive Approach to deliver the lesson.

- The learner in team explores and identifies the electrodes in different cell/battery and explains the choice.
- The learner in team explains the choice of electrodes based on electrochemical series.
- The learner in team explores and explains other applications of electrochemical series.
- The learner explains the choice of electrodes and other applications of electrochemical series (E.C. series) using PowerPoint presentation.
- Based on the knowledge of E.C. series, the learner designs a metallic container that may be used to store metal salt solution in the laboratory.
- The learner shares the design of the container to the class for feedback and comment.

SHE and e.m.f. of Cell

The teacher may use Computational Thinking to deliver the lesson.

- The learner in pair discusses why absolute electrode potential of an electrode cannot be measured.
- Based on the discussion, the learner explores and explains the technique to measure the electrode potential of a given electrode.
- The learner presents the working of SHE as a reference electrode using simulation/video/PowerPoint.
- The learner writes the expression for e.m.f. at standard condition.
- The learner calculates e.m.f of a galvanic cell at standard conditions using the expression.
- The learner submits the work to the teacher for feedback and comment.
- The learner writes Nernst equation to calculate the e.m.f. of galvanic cell at non-standard conditions.
- The learner solves practice problems on Nernst equation and submits the work to the teacher for feedback and comment.
- The learner evaluates the use of electrochemical cell in an electric car in terms of energy efficiency, renewability and environmental impact.

- The learner designs and constructs an electrochemical cell using lemons or any other fruits or vegetables to light a torch, LED bulb etc.
- The learner measures the e.m.f. of the cell using different number of lemons or fruits or vegetables, records the observation and explains the chemistry behind the observation.
- The learner presents the findings to the class.

Assessment:

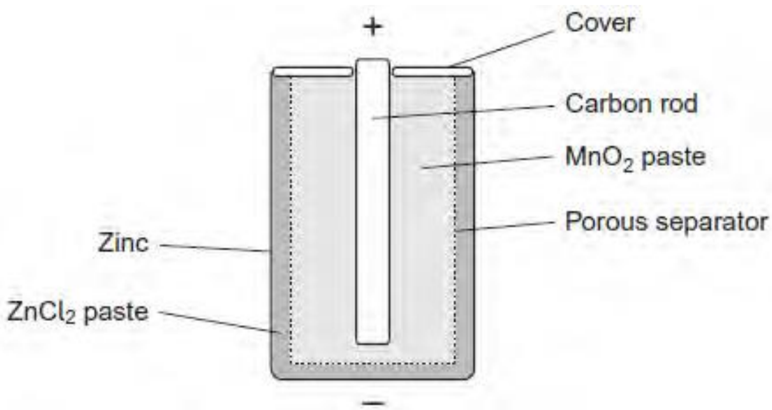
- The teacher may use assessment techniques such as question answer, DARTs, game, crossword puzzle, review, report writing, etc. to assess the learner's conceptual understanding of electrochemical cell, electrochemical series and e.m.f. of cell.
- The teacher may assess the learner's skills in information management, collaboration, communication, presentation, computation, differentiation, investigation, analysis and creation while designing experiment and constructing device, and exploring information on redox equilibria.
- The teacher may design rubric or checklist to assess the learner and accordingly provide necessary intervention.
- For recording and reporting, refer National School Curriculum Framework (NSCF-2021).

Resources:

- REC repository
- National School Curriculum Framework 2021
- Textbook of chemistry Class XII (2017) S.Chand Publisher.

Challenge Your Thinking

1. Sonam designs a device similar to the one shown in the figure. This device can be used to power electronic gadgets. Given that E0 Zn^{2+} = - 0.76V and E0 Mn^{2+} = 0.74.



With reference to the device, answer the following questions.

(i) Identify the cathode and the anode.

(ii) Calculate the emf of the cell
(iii) Write equation for the overall reaction when the cell is discharges
(iv) Suggest one function of carbon rod in the cell
(v) State one environmental disadvantage of this device.

2. (a) A galvanic cell is constructed using two divalent metals X and Y electrolytic solutions containing equal concentrations of reversible ions. It is observed that the current flows from Y to X. Which metal has higher oxidation potential?

   (b) The standard reduction potentials of copper and zinc electrodes are +0.35V and +0.80 V respectively. For the cell,

$$Zn/Zn^{2+} \; || \; Cu^{2+}/Cu$$

   i. Write the cell reaction
   ii. Calculate the emf of the cell
   iii. Is the cell reaction spontaneous? Why?

1.2.1.3 Chemical Kinetics

- Rate of Reaction (*Scope: rate law equation, definition and units of rate constant, characteristics of rate constant, collision theory, factors affecting the rate of reaction (nature of reactants, concentration of reactants, surface area of reactants, catalyst, temperature, light*).
- Molecularity and Order of Reaction (Scope: *definition and classification of molecularity with examples, order of reaction: zero, first and second order of reaction, rate vs. concentration graph for zero, first and second order, rate determining steps and reaction mechanism, units of rate constants, experimental determination of order of reaction: determination of rate equation by initial concentration method*).

Learning Experiences:

Rate of Reaction

The teacher may use Research, Evidence and Inference (REI) to deliver the lesson.

- The learner explores the importance of rate of reaction in daily life.
- The learner shares the findings in the class.
- The learner designs an experiment and carries out the investigation to demonstrate the rate of reaction. (The design may be Starch-Iodine Clock reaction).
- The learner presents the findings of the investigation to explain the rate of reaction.
- Based on the rate of reaction, the learner writes the expression for rate law and rate constant with reference to the law of mass action.
- The learner explores the characteristics of rate constant.

- The learner solves the numerical problems using rate of reaction and rate law equation.
- The learner submits the work to the teacher for feedback and comment.
- The learner designs an experiment to investigate the factors affecting the rate of reaction.
- The learner applies the knowledge of the factors affecting the rate of reaction to design chemical processes for industry to save time and optimize product.
- The learner carries out chemistry project based on the knowledge on chemical kinetics such as propelling rocket, boat etc.

Molecularity and Order of Reaction

The teacher may use Computational Thinking to deliver the lesson.

- The learner uses the video link *https://www.youtube.com/watch?v=aBphM8FIafU* to explore the molecularity of the reaction and prepares power notes on molecularity of the reaction.
- The learner interprets the data provided by the teacher to identify different order of reaction.
- Based on the information, the learner compares and writes the differences between molecularity and order of the reaction.
- The learner shares the comparison to the class.
- The learner deduces the units of rate constant using graphs and relevant mathematical data.
- The learner explains the rate determining step in a multi-step chemical reaction by using analogy.
- The learner determines the order of reaction and rate constant by using the mathematical expression and experimental data.
- The learner solves numerical problems on order of reaction, rate constant and rate law.
- The learner submits the work to the teacher for feedback and comment.

Assessment:

- The teacher may use assessment techniques such as question answer, DARTs, game, crossword puzzle, review, report writing, etc. to assess the learner's conceptual understanding of rate of reaction, molecularity and order of reaction.
- The teacher may assess the learner's skills in information management, collaboration, communication, presentation, computation, differentiation, investigation, analysis, and creation while designing experiment and exploring information on chemical kinetics.
- The teacher may design rubric or checklist to assess the learner and accordingly provide necessary intervention.

- For recording and reporting, refer National School Curriculum Framework (NSCF-2021).

Resources:

- REC repository
- National School Curriculum Framework 2021
- Textbook of chemistry Class XII (2017) S.Chand Publisher.
- *https://www.youtube.com/watch?v=aBphM8FIafU*

Challenge Your Thinking

1. (a) A student obtains the following data for the reaction

   $2A + B \longrightarrow 3C$ and the data is recorded in the Table below;

Experiment	[A]0(mol/L)	[B]0 (mol/L)	Initial rate(mol/L.s)
1	0.10	0.10	2.0x10-4
2	0.30	0.30	6.0x10-4
3	0.10	0.30	2.0x10-4
4	0.20	0.40	6.0x10-4

Use the data to answer the following questions

(i) Determine the rate law

(ii) What is the overall order of reaction.

(iii) Calculate the value of k for the reaction.

(iv) Define order of reaction.

(b) State and explain the effect of the following on the rate of reaction.

i. Increasing the temperature.

ii. Increasing the pressure.

iii. Increasing the concentration of one of the reactants.

iv. Adding a catalyst.

2. In each case what will happen to the rate constant k?

1.2.1.4 Nuclear Chemistry

- Radioactive Elements (*Scope: brief history on discovery of radioactive elements*)
- Nature of Radioactive Elements (Scope: *brief description of n/p ratio with reference to stability of isotopes).*
- Types and Properties of Radioactive Rays (Scope: *penetrating power, ionization energy, biological damage*).
- Modes of Decay, Group Displacement Law and Transmutation (Scope: *equations for radioactive decay, half-life of radioactive elements, and*

illustration with examples of group displacement law, transmutation: nuclear reaction).

- Tracer Elements and Their Uses (Scope: *phosphorus 30 and 32, iodine 131, cobalt 60, sodium 24*).
- Impacts of nuclear materials on health, environment and international politics.

Learning Experiences:

The teacher may use Cooperative Learning to deliver the lesson.

- The learner writes the historical narratives of the discovery of radioactive substances and its impact on human life, society and environment.
- The learner shares the narratives to the class.
- The learner in team uses the periodic table to identify the elements, which are radioactive in nature.
- Based on the information, the learner in team explores the properties of radioactive substances.
- The learner in team uses the video link

  https://www.youtube.com/watch?v=VTHQYjkCqV0 to explore the properties of radioactive rays.
- Based on the properties of radioactive rays, the learner interprets the stability curve to explain radioactive disintegration of radioactive elements and modes of decay.
- The learner applies the knowledge of modes of decay to state group displacement law.
- The learner solves the numerical problems based on modes of decay and group displacement law and submits to the teacher for feedback and comment.
- The learner uses video link

  https://www.youtube.com/watch?v=bOOXOtLvAao to explore nuclear transmutation.
- The learner prepares power notes on nuclear transmutation.
- The learner explores on half-life of radioactive elements to solve numerical problems.
- The learner evaluates the significance of radioactive substances including tracer elements with reference to energy source, medicine, research, agriculture, environment and politics.
- The teacher may invite guest teacher/speaker to share the impact brought by nuclear bombing at *Hiroshima* and *Nagasaki*. The teacher may also show the video using the link:

  https://www.youtube.com/watch?v=rcOFV4y5z8c and ask learners to write an argumentative essay on the use of nuclear energy.
- The teacher plans and conducts a debate on boon and bane of nuclear energy.

Assessment:

- The teacher may use assessment techniques such as question answer, DARTs, game, crossword puzzle, review, report writing, etc. to assess the learner's conceptual understanding of nature of radioactive elements, types and properties of radioactive rays, modes of decay, group displacement law, transmutation, tracer elements and their uses.
- The teacher may assess the learner's skills in information management, collaboration, communication, presentation, differentiation, computation, and analysis while exploring information on radioactivity.
- The teacher may design rubric or checklist to assess the learner and accordingly provide necessary intervention.
- For recording and reporting, refer National School Curriculum Framework (NSCF-2021).

Resources:

- REC repository
- National School Curriculum Framework 2021
- Text book of chemistry Class XII (2017) S.Chand Publisher.
- *https://www.youtube.com/watch?v=VTHQYjkCqV0*
- *https://www.youtube.com/watch?v=bOOXOtLvAao*
- *https://www.youtube.com/watch?v=rcOFV4y5z8c*

Challenge Your Thinking

1. Answer the following questions;
   (a) What is meant by half-life of a radioactive element?
   (b) A radioactive element has a half-life of 8 years. What is the weight of element left after 24 years, if the original weight of the element taken was I milligram**?**
   (c) What is nuclear fission? Writ a balanced equation for any one fission reaction.
2. Explain the effect of n/p ratio on nuclear stability.

1.2.1.5 Thermodynamics

- Basic Terms in Thermodynamics (Scope: *types of system: Open system, closed system, isolated system, macroscopic properties of a system: intensive and extensive systems, types of processes: reversible and irreversible processes, thermodynamic processes-isothermal, adiabatic, isobaric, isochoric, cyclic processes*).
- First Law of Thermodynamics (Scope: *statement, mathematical form of the law, limitations, internal Energy: definition, internal energy change, heat and work: positive and negative heat, work done in isothermal reversible and irreversible processes, enthalpy: definition, enthalpy change in chemical reaction, relationship between enthalpy and internal energy, numerical problems*).

- Entropy (Scope: *definition of entropy, change in entropy in reversible process, spontaneous and non-spontaneous processes: definition of spontaneous and non-spontaneous processes with examples, factors that determine the feasibility, or spontaneity of process*).
- Second Law of Thermodynamics (Scope: *statements of the law, Gibb's free energy and numerical problems*).

Learning Experiences:

Basic Terms in Thermodynamics

The teacher may use simulation/demonstration to deliver the lesson.

- The learner identifies real life examples to explain open, closed and isolated systems.
- The learner in team prepares a simulation or demonstration on open, closed and isolated systems.
- The learner compares intensive and extensive properties of a system using analogy.
- The learner uses PhET simulation link *https://phet.colorado.edu/en/simulation/legacy/reversible-reactions or video link https://phet.colorado.edu/en/simulation/legacy/reversible-reactions* to explore and explain thermodynamic processes.
- The learner identifies day-to-day life applications of thermodynamic processes and shares to the class.

First Law of Thermodynamics

The teacher may use Computational Thinking to deliver the lesson.

- The learner in team identifies real life examples of energy conversion and relates them to law of conservation of energy.
- Based on the relationship between the energy conversion and law of conservation of energy, the learner states the first law of thermodynamics.
- The learner converts the statement of internal energy into the mathematical expression, which is the equation for first law of thermodynamics.
- The learner applies mathematical expressions and data to calculate heat and work done in a system.
- The learner submits the work to the teacher for feedback and comment.
- The learner explores the limitations of the first law of thermodynamics.
- The learner designs and carries out an experiment to investigate enthalpy change in a chemical reaction.
- The learner records the observation and calculates the change in enthalpy.
- The learner establishes the relationship between enthalpy and internal energy using relevant mathematical expressions.
- The learner solves the numerical problems on enthalpy and internal energy for chemical reactions.

- The learner submits the work to the teacher for feedback and comment.

Entropy and Second Law of Thermodynamics

The teacher may use Inductive Approach to deliver the lesson.

- The learner in team explores different physical and chemical processes in the surrounding to identify spontaneous and non-spontaneous processes.
- The learner in team uses video link *https://www.youtube.com/watch?v=870y6GUKbwc* to explain the significance of entropy in nature and relate it to spontaneous process.
- The learner explores and writes the statements for the second law of thermodynamics in relation to entropy and Gibb's free energy.
- The learner presents the statements for second law of thermodynamics and the relationship between entropy and Gibb's free energy for feedback and comment.
- The learner solves numerical problems using the expression of Gibb's free energy and entropy.
- The learner submits the work to the teacher for feedback and comment.
- The learner in team designs a fast defroster using the principles of thermodynamics and shares the design to the class.

Assessment:

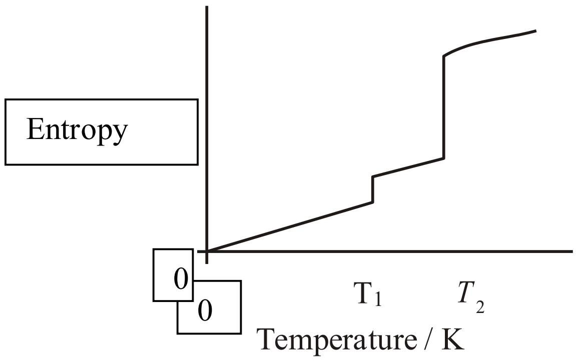
- The teacher may use assessment techniques such as question answer, DARTs, game, crossword puzzle, review, report writing, etc. to assess the learner's conceptual understanding of basic terms in thermodynamics, first law of thermodynamics, entropy and second law of thermodynamics.
- The teacher may assess the learner's skills in information management, collaboration, communication, presentation, differentiation, computation, investigation, analysis, and creation while designing an experiment and a prototype, and exploring information on thermodynamics.
- The teacher may design rubric or checklist to assess the learner and accordingly provide necessary intervention.
- For recording and reporting, refer National School Curriculum Framework (NSCF-2021).

Resources:

- REC repository
- National School Curriculum Framework 2021
- Textbook of chemistry Class XII (2017) S.Chand Publisher.
- *https://www.youtube.com/watch?v=870y6GUKbwc*
- *https://phet.colorado.edu/en/simulation/legacy/reversible-reactions*

Challenge Your Thinking

1. Figure below shows the variation of entropy of sample of water with change in temperature.



Refer the figure to answer the following questions.

i. Why is entropy of water zero at 0K?
ii. What change of state occurs at temperature *T*1?
iii. Explain why the entropy change, Δ*S*, at temperature *T*2 is much larger than that at temperature *T*1.
iv. It requires 3.49 kJ of heat energy to convert 1.53 g of liquid water into steam at 373 K and 100 kPa. Calculate the enthalpy change, Δ*H*, when 1.00 mol. of liquid water forms 1.00 mol. of steam at 373 K and 100 kPa.
v. Define entropy.

2. State the relationship between the changes in Gibbs energy, entropy and enthalpy in a reaction. Explain why the Gibbs energy change summarizes the consequences of the second law of thermodynamics for the spontaneous direction of reaction.
3. The second law of thermodynamics states that the entropy of the universe increases in all spontaneous changes. But some spontaneous reactions proceed with substantially negative values of $\Delta_r S^0$, E.G. $2CO(g) + 2NO(g) \longrightarrow 2CO_2(g) + N_2$ has $\Delta_r S^0 = -99 J\ mol^{-1} K^{-1}$. Explain how this is still consistent with the second law.

1.2.2 Materials and Change

Material and change is one of most fascinating aspects of chemistry. Different materials react in different ways which sometimes lead to the formation of new substances. Heat, light, water and catalyst are some of the agents that can bring about the change in materials. Under material and change, learners study carbonyl compounds, carboxylic acids, and carboxylic acid derivatives.

Competencies:

- Apply the knowledge of organic compounds and their interconversion to relate their importance and impact in daily life.

Objective(s):
Carbonyl Compounds

i. Write structural formula of carbonyl compounds and apply IUPAC rules to name them.
ii. Design an experiment to carry out the preparation of aldehydes and ketones.
iii. Design experiments to investigate the physical and chemical properties of aldehydes and ketones.
iv. Design 3D model of any carbonyl compounds using ICT or any other materials.
v. Explore the uses of aldehydes and ketones using relevant sources.
vi. Research to extract chemical substances containing aldehydes from local plants that can be used as preservatives, insecticides, perfumes and vaccines.
vii. Analyse the presence of formaldehyde in dry fish, vegetables and other products and find its impact on health.

Carboxylic Acids

viii. Write the structural formula and apply IUPAC rules to name carboxylic acids.
ix. Explore and design an experiment to prepare carboxylic acids.
x. Correlate the variation in physical properties of carboxylic acids with their structure.
xi. Compare the relative strength of different carboxylic acids.
xii. Design and carry out an experiment to extract vinegar from fruits that contain acetic acid and explore its uses.

Carboxylic Acid Derivatives

xiii. Write structural formula and apply IUPAC rules to name derivatives of carboxylic acid.
xiv. Design an experiment to prepare derivatives of carboxylic acids.
xv. Design an experiment to investigate the physical and chemical properties of derivatives of carboxylic acids.
xvi. Explore the uses of carboxylic acid derivatives through relevant sources.
xvii. Study the chemical composition in the different types of soap samples available in the market to compare the quality of the product.
xviii. Apply the knowledge of the chemical composition and saponification to prepare a soap sample that may be used in a community.
xix. Research on the quality of fats consumed by Bhutanese to assess the health risk associated with fats.
xx. Design a prototype to produce biofuel from oils, fats and local organic waste that may solve energy and environmental problems.

Amines

xxi. Use 2D/3D molecular models to compare aliphatic amines such as primary, secondary and tertiary amines and aromatic amines.
xxii. Design an experiment to demonstrate the preparation of amines.
xxiii. Design experiments to investigate the physical and chemical properties of amines.
xxiv. Explore the uses and the factors affecting the basic strength of amines.
xxv. Apply the knowledge of factors affecting basic strength of amines to compare the basicity of different amines.
xxvi. Outline the importance of amines in pharmaceutical industries.

- Narrate the nutritional value of amino acids to practice healthy dietary habit.

Objective(s):

Amino Acids

i. Use 2D/3D molecular model of amino acid to explain the structure of amino acids.
ii. Apply common and IUPAC naming system for amino acids.
iii. Examine the optical properties and amphoteric nature of amino acids in relation to its biological significance.
iv. Research to find out amino acid deficiency symptoms among local population in connection to vegetarian diet to prepare a news report.

1.2.2.1 Carbonyl Compounds

- Nomenclature of Carbonyl Compounds (Scope: *common naming system and IUPAC system of aldehydes (formaldehyde, acetaldehyde, benzaldehyde) and ketones (acetone)*).
- Preparation and Properties of Carbonyl Compounds (Scope: *preparation of aldehydes: formaldehyde from methanol, acetaldehyde from ethanol, benzaldehyde from toluene, physical properties of aldehydes: physical state, colour, odour, solubility, melting points and boiling points, polar nature of carbonyl group, dipole moment of aldehyde, chemical properties of aldehydes: Oxidation of aldehydes with acidified $K_2Cr_2O_7$, Tollen's reagent and Fehling's solution, reduction of aldehydes with $NaBH_4$, addition reaction of aldehydes with HCN, Cannizzaro reaction (formaldehyde and benzaldehyde), iodoform test for aldehydes, uses of aldehydes, preparation of ketones: acetone from isopropyl alcohol, physical properties of ketones: physical state, colour, odour, solubility, melting points and boiling points, polar nature of carbonyl group, dipole moment of ketones, chemical properties of ketones: reduction of ketones with $NaBH_4$, addition reaction of ketones with HCN, iodoform test for ketones, uses of ketone compounds*).

Learning Experiences:

Nomenclature and preparation of Carbonyl Compounds

The teacher may use Flipped Classroom to deliver this lesson.

The teacher prepares and uploads materials on nomenclature of carbonyl compounds and preparation of carbonyl compounds on Google Classroom or any other learning platforms two or three days before the lesson. The teacher may also prepare worksheets (*Refer Appendix 12(a) for sample*) on nomenclature and preparation of carbonyl compounds to check their understanding.

- The learner reads the uploaded materials and prepares power notes on nomenclature and preparation of carbonyl compounds.
- Using the power notes as reference, the learner completes the worksheets on nomenclature and preparation of carbonyl compounds provided by the teacher.
- The learner in team designs an experiment and carries out the preparation of an aldehyde/ketone.
- The learner in team carries out the chemical test to confirm the product. The learner in team shares the findings of the experiment to the class.

Properties of Carbonyl Compounds

The teacher may use Inquiry Based Learning (IBL) to deliver the lesson.

Teacher may prepare workstations to observe the physical and chemical properties of carbonyl compounds (acetaldehyde and acetone) with instructions and required materials. The teacher may prepare worksheets on physical and chemical properties of carbonyl compounds to check the understanding of the learner.

- The learner in team brainstorms to predict the types of chemical reaction that carbonyl compounds undergo based on the functional group.
- The learner in team reads the instruction provided by the teacher in each workstation and carries out the activity.
- The learner completes and submits the worksheets to the teacher for feedback and comment.
- The learner analyses the benefits and other implications of aldehydes and ketones.
- The learner explores and analyses the industrial significance of carbonyl compounds.
- The learner in team designs a research to extract preservatives, insecticides, perfumes and vaccines from local plants that contain aldehydes and shares with the teacher for feedback and comment.
- The learner may carry out the extraction and analysis of the product as part of project work.
- The learner in team shares the findings of the research on Google classroom or any other learning platform.

Assessment:

- The teacher may use assessment techniques such as question answer, DARTs, game, crossword puzzle, review, report writing, etc. to assess the learner's conceptual understanding of nomenclature, preparation, physical properties and chemical properties of carbonyl compounds.
- The teacher may assess the learner's skills in information management, collaboration, communication, presentation, differentiation, investigation, analysis and creation while designing experiment, carrying out the research and exploring information on carbonyl compounds.
- The teacher may design rubric or checklist to assess the learner and accordingly provide necessary intervention.
- For recording and reporting, refer National School Curriculum Framework (NSCF-2021).

Resources:

- National School Curriculum Framework 2021
- REC repository
- Chand, S. (2017). Textbook of chemistry Class XII.
- *https://www.youtube.com/watch?v=X1V2Xl-n1g8&t=438s*
- *https://www.odysseyware.com/blog/using-classpace-flipped-classroom*
- *https://www.youtube.com/watch?v=65yxWnpkC1Q*

Challenge Your Thinking

(1) Formaldehyde is the first member of aldehyde homologous series of aldehyde. Several studies have shown that exposure to formaldehyde has increased risk of cancer in humans. With reference to formaldehyde, answer the following questions.

i. What do you observe when formaldehyde is warmed with Tollen's reagent?
ii. Write a balanced equation for the above reaction
iii. Why does formaldehyde undergo Cannizaro reaction?
iv. Write a balanced equation for the Cannizaro reaction.
v. Mention health and environmental impact of formaldehyde.

(2) Ketones are widely used as solvents and as intermediates in the chemical industry. One member of ketone family is acetone with the formula CH_3COCH_3. With reference to the information, answer the following questions

i. Acetone undergoes reaction with HCN. What is the name of this reaction?
ii. Write the balanced equation for the above reaction.
iii. Acetone reacts with 2, 4 -dinitrophenyl hydrazine to form a yellow precipitate. What is the yellow ppt. due to and write the balanced chemical equation for the reaction
iv. Mention one health impact of acetone.

1.2.2.2 Carboxylic Acids

- Nomenclature of Carboxylic Acids (Scope: *common naming system and IUPAC system (formic acid, acetic acid, benzoic acid and oxalic acid*).
- Preparation and Properties of Carboxylic Acids (Scope: *preparation of formic acid from methanol, preparation of acetic acid from ethanol, preparation of oxalic acid from cane sugar, preparation of benzoic acid from benzyl alcohol, physical properties of carboxylic acid: physical state, colour, odour, solubility in water due to hydrogen bonding, boiling points and melting points of carboxylic acid, chemical properties of carboxylic acid: neutralisation reaction of carboxylic acids with NaOH, Na_2CO_3 and $NaHCO_3$, esterification reaction with ethanol, uses of carboxylic acids*).

Learning Experiences:

Nomenclature and Preparation of Carboxylic Acids

The teacher may use Cooperative Learning to deliver this lesson.

The teacher may prepare worksheets on nomenclature and preparation of carboxylic acids.

- The learner in team discusses the rules for nomenclature of carboxylic acids.
- The learner applies the rules to complete the worksheet on nomenclature of carboxylic acids and submits to the teacher for feedback and assessment.
- The learner explores and identifies carboxylic acids present in different food products.
- The learner in team shares to the class the list of food items that contains carboxylic acid.
- The learner in team designs experiments on the preparation of formic acid, acetic acid, benzoic acid and oxalic acid.
- The learner in team presents the design of the experiment on preparation of carboxylic acid to the class for feedback and comment.
- The learner completes the worksheet on preparation of carboxylic acids to the teacher for feedback and comment.
- The learner designs and carries out an experiment to extract vinegar from fruits that contain acetic acid and explore its uses.
- Assess the health and ecological hazards associated with carboxylic acids.

Properties of Carboxylic Acids

The teacher may use 7E model (Elicit-Engage-Explore-Explain-Elaborate-Evaluate-Extend) to deliver the lesson.

The teacher may prepare a task on TED-Ed for the learner.

Elicit

- The learner recapitulates the preparation of carboxylic acids using Think-Pair-Share.

- The learner notes down the formula and functional group of carboxylic acid.

Engage

- The learner observes the reaction between vinegar and baking soda demonstrated by the teacher.
- The learner explains the reaction of vinegar with baking soda based on the presence of functional group of carboxylic acid.

Explore

- The learner in team brainstorms to predict the physical properties of carboxylic acids and chemical reactions based on the functional group.
- The learner in team explores the physical and chemical properties of carboxylic acids using TED-Ed.

  Refer the link *https://www.youtube.com/watch?v=1fL9YIxMB88&t=87s* to create a lesson on TED-Ed.

Explain

- The learner in team shares the physical and chemical properties of carboxylic acids to the class.

Elaborate

- The learner in team designs an experiment to investigate any physical and chemical property of carboxylic acid.
- Based on the design, the learner in team carries out the experiment to investigate the properties of carboxylic acid.
- The learner records the observation and discusses in the class.

Evaluate

- The learner is assessed through quiz, puzzle, and question-answer on properties of carboxylic acid.

Extend

- The learner analyses the benefits and other implications of carboxylic acids and shares with the class.
- The learner shares the work to the class.

Assessment:

- The teacher may use assessment techniques such as question answer, DARTs, game, crossword puzzle, review, report writing, etc. to assess the learner's conceptual understanding of nomenclature, preparation, properties and uses of carboxylic acids.
- The teacher may assess the learner's skills in information management, collaboration, communication, presentation, differentiation, investigation, analysis, and creation while designing experiment and exploring information on carboxylic acids.
- The teacher may design rubric or checklist to assess the learner and accordingly provide necessary intervention.

- For recording and reporting, refer National School Curriculum Framework (NSCF-2021).

Resources:

- National School Curriculum Framework 2021
- REC repository
- Srivastava,H.C. (2016-2017,10th Ed,). ISC Chemistry Class XII. Nageen Prakash (Pvt.) Ltd. Western Kutchery Road, Meerut-250 002, U.P. (INDIA).
- Chand, S. (2017). Textbook of chemistry Class XII.
- *https://www.youtube.com/watch?v=LR5TNtznOfA*
  https://www.youtube.com/watch?v=1fL9YIxMB88&t=87s

Challenge Your Thinking

1. 'A' is an organic compound made of C, H and O. It has a vapour density of 15. On reduction, 'A' gives a compound X which has the following properties.
   - 'X' is a colourless liquid miscible with water.
   - 'X' is neutral to litmus.
   - When 'X' is warmed with a few drops of conc. H2SO4 followed by a little salicylic acid, a characteristic smell is produced.
     When 'X' is subjected to strong oxidation, it gives a compound 'B' which has the following properties:
     - 'B' is pungent smelling mobile liquid
     - It is miscible with water , alcohol or ether
     - It can be obtained by passing the vapous of 'A' with air over platinum black catalyst.
     - It is corrosive
     - It liberates H2 with sodium
     - It gives CO_2 with $NaHCO_3$

   i. What is the molecular weight of A
   ii. Identify A, X and B
   iii. Give appropriate reactions to confirm A , X and B
   iv. State one use each of A, X and B.

2. (a) What do you observe when formic acid is treated with Tollen's reagent
   (b) What happens when glacial acetic acid is treated with PCl_5?
   (c) Write the balanced chemical equation for the reaction between oxalic acid and $KMnO_4$ in presence of H_2SO_4. Why the solution is initially warmed but not continuously.

1.2.2.3 Carboxylic Acid Derivatives

- Acyl Halides-Acetyl Chloride (Scope: *nomenclature: common naming system and IUPAC naming system of acyl halides, preparation of acetyl chloride: from glacial acetic with PCl_5 and $SOCl_2$, Physical properties of acetyl chloride: physical state, smell, solubility and boiling point, chemical* *properties of acetyl chloride: mechanism of nucleophilic addition elimination reaction, hydrolysis, alcoholysis, ammonolysis, reaction with ethyl amine, uses of acetyl chloride*).

- Esters-Ethyl Acetate (Scope: *common naming system and IUPAC naming system of esters, preparation of ethyl acetate: from glacial acetic and ethanol in the presence of conc.* H_2SO_4*, physical properties of ethyl acetate: physical state, boiling point and solubility, chemical properties of ethyl acetate: hydrolysis in acidic and alkaline medium, saponification, uses of ethyl acetate*).
- Fats and Oils (Scope: *definition of saturated and unsaturated fats, health risk of saturated fats, biodiesel: manufacture of biodiesel from reaction between carboxylic acid and methanol*).
- Alkanamides-Acetamide (Scope: *nomenclature: common naming system, IUPAC naming system of alkanamides, preparation of acetamide: distillation of ammonium acetate in presence of glacial acetic acid, physical properties of acetamide: physical state, solubility, odour, melting and boiling points, chemical properties of acetamide: hydrolysis in acidic medium and alkaline medium, reduction in presence of sodium-metal and absolute alcohol, Hoffman's degradation reaction and its significance in organic synthesis, uses of acetamide*).

Learning Experiences:

Acyl halides-Acetyl Chloride

The teacher may use Blended Learning (BL) to deliver the lesson.
The teacher uploads the materials on nomenclature and preparation of acyl halide.

- The learner reads the uploaded materials and makes power notes on nomenclature and preparation of acyl halide.
- Using the power notes as reference, the learner completes the worksheets on nomenclature and preparation of acyl halide provided by the teacher in the class.
- The learner designs an experiment for the preparation of acyl halide.
- Based on the design, the learner completes the worksheet.
- The learner submits the worksheet to the teacher for feedback and comment.

Properties of Acyl Halide

The teacher may use Cooperative Learning to deliver the lesson. The teacher may provide worksheets on physical and chemical properties of acyl halide.

- The learner in team brainstorms to predict the types of chemical reaction that acyl halide undergoes based on the functional group.
- The learner explores the information on physical and chemical properties of acyl halide to verify the prediction.

- The learner shares the work to the class for feedback and comment.
- The learner uses a video link *https://www.youtube.com/watch?v=BxoqLwr2zaE* to study the reaction mechanism of nucleophilic addition-elimination reaction.
- Based on the information from the video, the learner completes the worksheets on reaction mechanism and submits the worksheets to the teacher for feedback and comment.
- The learner analyses the benefits and other implications of acyl halides and shares the work to the class for feedback and comment.

Esters-Ethyl Acetate

Nomenclature and Preparation of Ethyl Acetate

The teacher may use Blended Learning (BL) to deliver the lesson. The teacher uploads the materials on nomenclature and preparation of ethyl acetate.

- The learner reads the uploaded materials and makes power notes on nomenclature and preparation of ethyl acetate.
- Using the power notes as reference, the learner completes the worksheets on nomenclature and preparation of ethyl acetate provided by the teacher in the class.
- The learner designs and carries out the experiment for preparation of ethyl acetate.
- Based on the experiment, the learner completes the worksheet and submits to the teacher for feedback and comment.

Properties of Esters

The teacher may use Cooperative Learning to deliver the lesson. The teacher may provide worksheets on physical and chemical properties of ethyl acetate.

- The learner in team brainstorms to predict the types of chemical reaction that ethyl acetate undergoes based on the functional group.
- The learner explores the information on physical and chemical properties of ethyl acetate to verify the prediction.
- The learner in team investigates the chemical composition in the different types of soap samples available in the market to compare the quality of the product.
- The learner applies the knowledge of the chemical composition and saponification to prepare a soap sample that may be used in a community. The learner advertises the product in appropriate forums.
- The learner shares the work on physical and chemical properties of esters to the class for feedback and comment.

- The learner analyses the benefits and other implications of ethyl acetate and shares the work to the class for feedback and comment.

Fats and Oils

The teacher may use Research, Evidence and Inference (REI) to deliver the lesson.

- The learner explores the information on saturated and unsaturated fats through relevant sources.
- The learner carries out research on the quality of food consumed by Bhutanese to assess the health risk associated with fats.
- The learner makes a presentation to the class or publishes the findings in the school journal/national journal/international journal.
- The learner explores the manufacture of biodiesel using relevant sources.
- The learner in team designs a prototype to produce biofuel from local organic waste that may solve energy problems in the locality.
- The learner shares the design with the teacher for feedback and comment.
- The learner in team discusses and evaluates the environmental significance of biofuel.
- The learner presents the work to the class.

Alkanamides-Acetamide

The teacher may use Jigsaw strategy to deliver the lesson. The teacher may divide the class into five expert teams and assigns a topic (nomenclature, preparation, physical properties, chemical properties and uses of alkanamides) to each team.

- The learner in expert team discusses the nomenclature, preparation, physical properties, chemical properties and uses of alkanamides.
- The learner shares the nomenclature, preparation, physical properties, chemical properties and uses of alkanamides in home team.
- The learner in team prepares PowerPoint presentation and presents to the class for feedback and comment.

Assessment:

- The teacher may use assessment techniques such as question answer, DARTs, game, crossword puzzle, review, report writing, etc. to assess the learner's conceptual understanding of nomenclature, preparation, physical properties, chemical properties and uses of carboxylic acid derivatives.
- The teacher may assess the learner's skills in information management, collaboration, communication, presentation, differentiation, investigation, analysis, and creation while designing experiments, prototype and preparing soap sample, and exploring information on carboxylic acid derivatives.

- The teacher may design rubric or checklist to assess the learner and accordingly provide necessary intervention.
- For recording and reporting, refer National School Curriculum Framework (NSCF-2021).

Resources:

- REC repository
- National School Curriculum Framework 2021
- Text book of chemistry Class XII (2017) S.Chand Publisher.
- *https://www.youtube.com/watch?v=BxoqLwr2zaE*

Challenge Your Thinking

1) (a) Write equations for the following.
    i) Acetyl chloride reacts with ethyl alcohols.
    ii) Acetyl chloride reacts with ammonia solution.
    iii) Acetyl chloride reacts with ethyl amine.

   (b) Explain the mechanism of nucleophilic addition – elimination reaction of acetyl chloride

   (c) What happens when oils and fats are heated with caustic soda solution?

2) Answer the following questions;
    i. What is soap?
    ii. What is this reaction called?
    iii. Name the by-product formed.

1.2.2.4 Amines

- Classification and Nomenclature of Amines (Scope: *Classification of amines: aliphatic amines, aromatic amines, nomenclature of amines: common naming system, IUPAC naming system*).
- Preparation and Properties of Amines (Scope: *Preparation of amines: Preparation of methyl amine from methyl iodide in excess of alcoholic ammonia, preparation of ethylamine from ethane nitrile, preparation of aniline from nitrobenzene, Physical properties: Physical state, colour, odour, solubility and boiling point, Chemical properties: Reaction of amines with water and acids, factors affecting basic strength of amines, basic strength among ammonia, primary aliphatic amine and primary aromatic amine, uses of amines*).

Learning Experiences:

The teacher may use 'Build Your Model' to deliver the lesson. The teacher uploads the materials on classification, nomenclature and preparation of amines. The teacher provides worksheets on classification, nomenclature and preparation of amines.

- The learner studies the uploaded materials and makes power notes on classification, nomenclature and preparation of amines.
- Using the power notes as reference, the learner completes the worksheets on classification, nomenclature and preparation of amines provided by the teacher in the class.
- The learner submits the worksheet for feedback and comment.
- The learner in team constructs physical or computer molecular models to compare different types of amines.
- The learner designs an experiment for the preparation of amines.
- The learner presents the design to the class for feedback and comment.

Properties of Amines

The teacher may use Cooperative Learning to deliver the lesson. The teacher may provide worksheets on physical and chemical properties of amines.

- The learner in team brainstorms to predict the types of chemical reaction that amines undergoes based on the functional group.
- The learner explores the information on physical and chemical properties of amines to verify the prediction.
- The learner designs experiments to investigate the physical and chemical properties of amines.
- The learner shares the work to the class for feedback and comment.
- The learner uses the video link *https://www.youtube.com/watch?v=T3EdL1vs48Q* to study the factors affecting the basic strength of amines and the uses of amines.
- Based on the video link, the learner completes the worksheet to compare the basicity of amines.
- The learner submits the worksheet to the teacher for feedback and assessment.
- The learner analyses the benefits and other implications of amines and shares the work to the class for feedback and comment.
- The learner explores the importance of amines in pharmaceutical industries and shares to the class.

Assessment:

- The teacher may use assessment techniques such as question answer, DARTs, game, crossword puzzle, review, report writing, etc. to assess the learner's conceptual understanding of classification, nomenclature, preparation and properties of amines.
- The teacher may assess the learner's skills in information management, collaboration, communication, presentation, differentiation, analysis, and creation while designing experiments and model, and exploring information on amines.
- The teacher may design rubric or checklist to assess the learner and accordingly provide necessary intervention.

- For recording and reporting, refer National School Curriculum Framework (NSCF-2021).

Resources:

- REC repository
- National School Curriculum Framework 2021
- Text book of chemistry Class XII (2017) S.Chand Publisher.
- *https://www.youtube.com/watch?v=T3EdL1vs48Q*
- *https://www.youtube.com/watch?v=aBphM8FIafU*

Challenge Your Thinking

1) An aliphatic organic compound A on treatment with nitrous acid gave a product B. B on oxidation gave compound C which gave iodoform on treatment with iodine and alkali and had molecular weight 58. Identify the compound A, B and C.

2) Write the reactions for the following;
   i. Reaction of ethyl amine with water.
   ii. Reaction of ethyl amine with HCl.

3) (a) Arrange the following in increasing order of their basicity
   NH_3, $(CH_3)2NH$, CH_3NH_2, $C_2H_5NH_2$

   (b) Explain for the increase order of basicity for the above compounds.

1.2.2.5 Amino Acids

- Amino Acids:(Scope: *general structure and formula of amino acids, nomenclature of amino acids: common naming system, IUPAC naming system, optical properties: optical activity of amino acids, zwitter ion: definition of zwitter ion, formation of zwitter ion in neutral aqueous solution, amphoteric character of amino acids, migration of zwitter ion in acidic and basic medium, definition of isoelectric point and characteristics of isoelectric point*).

Learning Experiences:

The teacher may use Substitution-Augmentation-Modification-Redefinition Model (SAMR) to deliver the lesson. The teacher prepares a lesson using TED-Ed (Refer link *https://ed.ted.com/on/enwUOTUt* for sample). The lesson may contain video link, reading materials and worksheets on nomenclature, structure, optical properties and amphoteric nature of amino acids.

- The learner uses TED-Ed to study the nomenclature, structure, optical properties and amphoteric nature of amino acids.
- The learner in team constructs 3D molecular model of amino acid to explain the structure of amino acids.

- The learner completes the worksheets on nomenclature, optical properties and amphoteric nature of amino acids and submits to the teacher for feedback and comment.
- The learner explores the biological significance of amino acid in relation to its optical properties and amphoteric nature
- The learner shares the work to the class.
- The learner carries out research to find out amino acid deficiency symptoms among local population in connection to vegetarian diet and prepares a News report.

Assessment:

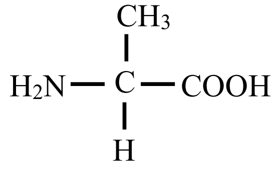
- The teacher may use assessment techniques such as question answer, DARTs, game, crossword puzzle, review, report writing, etc. to assess the learner's conceptual understanding of nomenclature, structure, optical properties and amphoteric nature of amino acids.
- The teacher may assess the learner's skills in information management, collaboration, communication, differentiation, investigation, analysis, and creation while designing model and exploring information on amino acids.
- The teacher may design rubric or checklist to assess the learner and accordingly provide necessary intervention.
- For recording and reporting refer National School Curriculum Framework (NSCF-2021).

Resources:

- REC repository
- National School Curriculum Framework 2021
- Text book of chemistry Class XII (2017) S.Chand Publisher.
- *https://ed.ted.com/on/enwUOTUt*

Challenge Your Thinking

1) Amino acids are monomers of protein and proteins are building blocks of life. The structural formula of alanine is



With reference to alanine, answer the following questions;

(i) What is carbon atom called in alanine?

(ii) Draw the structure of the main alanine species present in the aqueous solution.

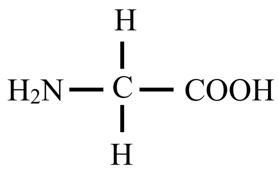
(iii) Give the name of this species.

(iv) Draw the structure of alanine species when excess of HCl is added to the solution.

(v) Alanine molecules react together to form a polypeptide. Give the repeating unit of this polypeptide and name the type of polymerization involved in its formation.

(vi) Comment on some of the deficiency diseases related to amino acids.

2) The structure of amino acid glycine is shown below.



With reference to the above compound, answer the following questions;

(i) Give the IUPAC name of glycine.

(ii) Draw the structure of the species formed by glycine at isoelectric point.

(iii) Draw the structure of a dipeptide formed when two molecules of glycine are joined by a peptide bond.

1.2.3 Pattern in Chemistry

Pattern is a regular sequence that can be found in nature. Patterns in chemistry are observed in periodic trends in periodic table, pattern in types of chemical reactions and energy transfer. Under patterns in chemistry, learners study colligative properties, coordination chemistry and analytical chemistry.

Competencies

- Relate the principle of colligative properties to day-to-day applications in improving the quality of life.

Objective(s):

Colligative Properties

i. Deduce the units of molarity, molality, normality and mole fraction for expressing concentration of the solution.

ii. Solve numerical problems related to concentration of solutions and colligative properties.

iii. Design and carry out an experiment to prepare standard solutions that can be used in the laboratory based on the principles of molarity, molality and normality.

iv. Determine relative molecular mass (RMM) of solute using colligative properties.

v. Formulate a car coolant, which does not freeze in winter based on the principles of colligative properties.

vi. Design a chemical process to show impact of colligative properties on taste and quality of food.

- Apply the knowledge of coordination chemistry to enhance the production in industries and understand the functioning of biological systems.

  Objective(s):
  Coordination Chemistry

  i. Justify the position of transition elements in the periodic table.
  ii. Explore the characteristics of transition elements.
  iii. Classify ligands on the basis of charge and mode of attachment.
  iv. Apply knowledge of Werner's theory to determine the primary and secondary valencies of coordination compounds.
  v. Construct 2D/3D models of coordination compounds to explain the structure of coordination compounds based on Werner's theory.
  vi. Apply IUPAC rules to name coordination complexes and write their formula.
  vii. Explain the colours exhibited by coordination compounds based on crystal field splitting.
  viii. Evaluate the importance of coordination compounds in industries and biological systems.
  ix. Construct 2D/3D models of haemoglobin, chlorophyll, cis-platin, etc to relate the importance of coordination complexes.
  x. Create a new hypothetical 2D/3D model of a coordination complex that may have some applications in life.

- Apply analytical techniques for qualitative and quantitative analysis in industries, research, space and forensic science.

  Objective(s):
  Analytical Chemistry

  i. Explore the definition and basic steps in analytical techniques.
  ii. Design an experiment to conduct a chemical analysis of a sample of beverage available in the market.
  iii. Explore the working principle, instrumentation and use of TLC, HPLC, mass spectrometry, IR spectroscopy and NMR spectroscopy using relevant resources.
  iv. Analyse the importance of NMR in the medical field.
  v. Interpret mass spectrum and the fragmentation pattern of a molecular ion and daughter ions.
  vi. Determine the molecular mass of an organic molecule from its molecular ion peak in a mass spectrum.
  vii. Analyse the presence of aromatic compounds present in the extracts of local plants.
  viii. Interpret concept of equivalent and non-equivalent proton, chemical shift, spin-spin coupling and (n+1) rule from NMR spectrum.
  ix. Interpret NMR spectra of aliphatic hydrocarbons
  x. Interview a forensic expert in JDWNRH or RBP headquarter or Pharmaceutical Institutes to explore the type of analytical techniques used.

1.2.3.1 Colligative Properties

- Concentration Units of Solution (Scope: *definition, expression and units of normality, molarity, molality and mole fraction, related numerical problems*).
- Colligative Properties of Solution (Scope: *relative lowering of vapour pressure: Effect of presence of solute in a solution on vapour pressure, expression of Raoult's law, determination of RMM, related numerical problems, elevation in boiling point: effect of presence of solute in a solution on boiling point: expression, determination of RMM, related numerical problems, depression in freezing point: effect of presence of solute in a solution on freezing point, expression, determination of RMM by Beckmann's method, related numerical problems, osmotic pressure: effect of presence of solute in a solution on osmotic pressure, expression, determination of RMM, related numerical problems, Van't Hoff Factor*).

Learning Experiences:

Concentration Units of Solution

The teacher may use Process Oriented Guided Inquiry Learning (POGIL) (Refer the link *https://serc.carleton.edu/sp/pkal/pogil/what.html* to explore on POGIL strategy) to deliver the lesson.

The teacher provides worksheets on comparison of different concentration units, derivation of units for different concentration units, relationship between molarity and normality and numerical problems based on concentration units of solution.

- The learner in team discusses the difference between dilute and concentrated solutions.
- The learner predicts the unit for measuring the concentration of the dilute and concentrated solutions.
- The learner in team follows the instruction given in the worksheets.
- The learner completes the worksheets and submits to the teacher for feedback and assessment.
- The learner in team designs and carries out an experiment to prepare standard solutions that can be used in the laboratory based on molarity, molality and normality.
- The learner investigates the industrial importance and application of concentration units of solutions by interviewing the chemist in AWP or any other relevant industry in Bhutan. The teacher may organize a field trip or online interview for this activity.

Relative Lowering of Vapour Pressure

The teacher may use Atkin and Karplus learning cycle to deliver the lesson.

Exploration

- The learner in team explores and discusses the effect of solute on vapour pressure of solvent.

Concept development

- The learner in team discusses the expressions for Raoult's law in relation to change in vapour pressure and RMM.
- The learner solves numerical problems based on Raoult's law and RMM.
- The learner submits the work to the teacher for feedback and comment.

Concept application

- The learner explores and analyses the choice of ethylene glycol over sodium chloride as coolant in the car radiator. The learner shares the findings to the class.

Elevation in Boiling Point

The teacher may use Kolb's Learning Cycle to deliver the lesson.

Concrete experience

- The learner carries out an experiment to observe the change in boiling point of water on adding solute.

Reflective observation

- The learner in team discusses the reason for change in boiling point of water on adding solute.

Abstract conceptualisation

- The learner in team draws conclusion for the experiment in relation to elevation in boiling point.
- The learner in team discusses the relationship between elevation in boiling point and molality.
- The learner in team discusses the expression for RMM in terms of elevation in boiling point of solution and writes the equation.
- Using the equation, the learner solves numerical problems.
- The learner submits the work to the teacher for feedback and comment.

Active experimentation

- The learner in team designs and carries out an experiment to investigate the effect of different types of solute on boiling point of solvent.

Depression in Freezing Point

The teacher may use Kolb's Learning Cycle to deliver the lesson.

Concrete experience

- The learner carries out an experiment to observe the change in freezing point of solvent on adding solute.

Reflective observation

- The learner in team discusses the reason for change in freezing point of solvent on adding solute.

Abstract conceptualisation

- The learner in team draws conclusion for the experiment in relation to depression in freezing point of solution.

- The learner in team discusses the relationship between depression in freezing point and molality.
- The learner in team discusses the expression for RMM in terms of depression in freezing point of solution and writes the equation.
- Using the equation, the learner solves numerical problems.
- The learner submits the work to the teacher for feedback and comment.

Active experimentation

- The learner formulates a car coolant, which does not freeze in winter based on the principles of colligative properties.
- The learner designs a chemical process to show impact of colligative properties on taste and quality of food.
- The learner shares the design to the class for feedback and comment.

Osmotic Pressure

The teacher may use Kolb's Learning Cycle to deliver the lesson.

Concrete experience

- The learner designs (*Refer Appendix 12(b) for sample*) and carries out an experiment to observe the phenomenon of osmosis.

Reflective observation

- The learner in team discusses the explanation for the observation of the experiment.

Abstract conceptualisation

- The learner in team draws conclusion for the experiment in relation to osmotic pressure.
- The learner in team calculates the value of osmotic pressure.
- The learner in team discusses the expression for RMM in terms of osmotic pressure of solution and writes the equation.
- Using the equation, the learner in team solves numerical problems.
- The learner submits the work to the teacher for feedback and comment.

Active experimentation

- Using the knowledge of osmotic pressure, the learner analyses the implication of higher dietary intake of common salt in hypertensive patient.
- The learner shares the analysis in the school health bulletin board.

Assessment:

- The teacher may use assessment techniques such as question answer, DARTs, game, crossword puzzle, review, report writing, etc. to assess the learner's conceptual understanding of concentration units and colligative properties of solution.
- The teacher may assess the learner's skills in information management, collaboration, communication, presentation, computation, differentiation,

investigation, analysis and creation while designing experiment, formulation of coolant and exploring information on colligative properties.

- The teacher may design rubric or checklist to assess the learner and accordingly provide necessary intervention.
- For recording and reporting, refer National School Curriculum Framework (NSCF-2021).

Resources:

- REC repository
- National School Curriculum Framework 2021
- Text book of chemistry Class XII (2017) S.Chand Publisher.
- *https://www.youtube.com/watch?v=OTt16CB4B1s*
- *https://www.youtube.com/watch?v=tgrhMYU1Q4w*
- *https://youtu.be/NIwHkecDgNQ*

Challenge Your Thinking

1) A student wanted to find the molar mass of an unknown solute X by the depression in freezing point method. The depression in freezing point is the colligative property of the solution. A solution was prepared by dissolving 0.5580g of an unknown solute X in 33.50 g cyclohexane. The freezing point of cyclohexane is 6.50 °C and the freezing point of the solution is 4.32 °C. (K_f for cyclohexane is 20.0 °C.kg/mole).

   With reference to the above experiment, answer the following questions.

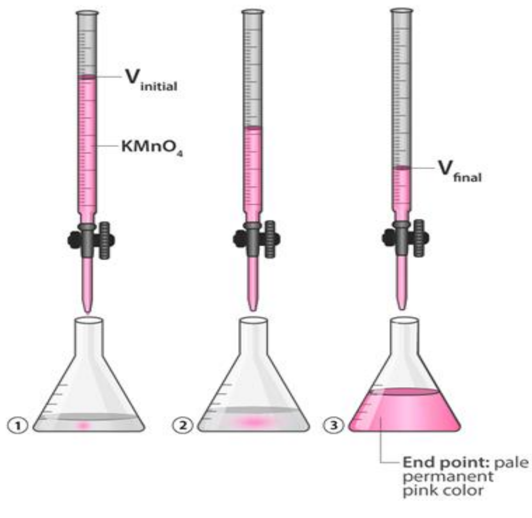
   (i) Calculate the molar mass of solute X.

   (ii) What is a colligative property?

   (iii) Freezing point is not a colligative property but depression in freezing point is. Explain.

   (iv) Mention two applications of colligative property.

2) Karma carried out permanganometric titrations using 0.1M oxalic acid solution and $KMnO_4$ solutions as shown in the figure below.



The equation for the reaction is given as

$$2KMnO_4 + 3H_2SO_4 + 5H_2C_2O_4 \rightarrow K_2SO_4 + 2MnSO_4 + 8H_2O + 10CO$$

The observation is recorded in the table below.

Sl.No	**Volume of oxalic acid** (mL)	**Volume of KMnO4 used** (mL)
1	20	19.1
2	20	19.0
3	20	19.0

Use the data in Table 3 to answer the following questions.

(i) Calculate the molarity of $KMnO_4$ solution.

(ii) Calculate the strength of $KMnO_4$ solution.

(iii) What is the specific name given to this permangnometric titrations?

(iv) Name the indicator used in the titration.

(v) Mention two precautions for the experiment.

1.2.3.2 Coordination Chemistry

- Transition Elements and Characteristics (Scope: *position of transition elements in periodic table, series of transition elements, electronic configuration, characteristics of transition elements: variable oxidation states, formation of coloured ions, formation of complex compounds, catalytic properties*).
- Terms in Coordination Compounds (Scope: *definition of central atom or ion, ligands, coordination spheres or coordination entity, ionic spheres, coordination number, oxidation number, charge of the complex, chelation, denticity, types of ligands: classification on the basis of charge, classification on the basis of mode of attachment*).
- Werner's Coordination Theory (Scope: *postulates of Werner's theory*)
- Nomenclature of Coordination Compounds (Scope: *rules for writing the formula of complex ion or compound, rules for writing the IUPAC name and formula of coordination complexes*).
- Colour Exhibited by Coordination Compounds (Scope: *factors on which colour depends-nature of metal ion and nature of ligands, explanation of colour of complexes using crystal field splitting*).
- Uses of Transition Metal Ion Complexes (Scope: *catalyst, medicine, reagents, biological importance*).

Learning Experiences:

Transition Elements and Characteristics

The teacher may use Cooperative Learning to deliver this lesson.

- The learner in team justifies the position of transition elements in the interactive periodic table.

- The learner in team observes different types of salts and segregates them into salts of transition elements and salts of non-transition elements.
- The learner in team analyses the chemistry behind the formation of coloured complexes by transition elements.
- The learner in team designs and carries out an experiment to demonstrate the formation of complexes and magnetic properties of transition metals.
- Based on the observation, the learner in team explores the characteristics of transition elements.
- The learner presents the characteristics of transition elements to the class using PowerPoint presentation for feedback and comment.

Terms in Coordination Compounds and Werner's Coordination Theory

The teacher may use SAMR model to deliver the lesson.

- The learner explores examples of some common complexes and identifies various components in a complex to explain central atom or ion, ligands, coordination spheres or coordination entity, ionic spheres, coordination number, oxidation number, charge of the complex, chelation and denticity.
- The learner prepares power note on these terms and submits to the teacher for feedback and comment.
- The learner identifies and classifies ligands on the basis of charge and mode of attachment.
- The learner uses the video link *https://youtu.be/EXvSl0zOxz8* to study Werner's coordination theory.
- The learner applies the knowledge of Werner's coordination theory to determine the primary and secondary valencies of coordination compounds.
- The learner constructs 3D models of coordination compounds to explain the structure of coordination compounds based on Werner's theory.
- The learner presents the model to the class.

Nomenclature of Coordination Compounds

The teacher may use Process Oriented Guided Inquiry Learning (POGIL) to deliver the lesson.

- The learner explores the IUPAC rules for nomenclature of coordination compounds under the guidance of the teacher.
- The learner follows the instructions and completes the worksheet. The worksheets contain practice problems to write the IUPAC name or formula of complexes.
- The learner submits the worksheet to the teacher for feedback and comment.

Colour Exhibited by Coordination Compounds and their Uses

The teacher may use Scientific Inquiry method to deliver the lesson.

- The learner examines and explains different colours exhibited by coordination compounds using relevant sources with reference to Crystal Field Splitting (CFS).
- The learner explores the factors affecting the colour in coordination compounds.
- The learner prepares a PowerPoint presentation to explain Crystal Field Splitting and factors affecting colour in coordination compounds and presents to the class.
- The learner evaluates the importance of coordination compounds in industries and biological systems and presents the findings to the class.
- The learner constructs 2D/3D model of haemoglobin, chlorophyll, cis-platin etc. to relate the importance of coordination complexes and shares the model to the class.
- The learner creates a new hypothetical 2D/3D model of a coordination complex that may have some applications in life and shares the model to the class.

Assessment:

- The teacher may use assessment techniques such as question answer, DARTs, game, crossword puzzle, review, report writing, etc. to assess the learner's conceptual understanding of characteristics of transition elements, terms in coordination compounds, Werner's coordination theory, and nomenclature of coordination compounds and uses of transition metal ion complexes.
- The teacher may assess the learner's skills in information management, collaboration, communication, presentation, differentiation, investigation, analysis, and creation while designing and constructing a model, and exploring information on coordination compounds.
- The teacher may design rubric or checklist to assess the learner and accordingly provide necessary intervention.
- For recording and reporting, refer National School Curriculum Framework (NSCF-2021).

Resources:

- REC repository
- National School Curriculum Framework 2021
- Text book of chemistry Class XII (2017) S.Chand Publisher.
- *https://www.youtube.com/watch?v=EXvSl0zOxz8*

Challenge Your Thinking

1) $[CoBr(NH_3)_5]SO_4$ and $K_4[Fe(CN)_6]$ are two coordination compounds. With reference to the coordination compounds, answer the following questions;
   (i) Why do transition elements form coordination compounds?
   (ii) Mention one characteristic features of coordination compounds.

(iii) Calculate the oxidation number in the above two compounds and give IUPAC name of the compounds.
(iv) Identify the ligands and central metal atom in the above compounds
(v) Mention one biological significance of coordination compound.

2) Write the IUPAC name for the following compounds
   i. $K_2[Fe(CN)_3(Cl)_2(NH_3)]$
   ii. $[Cr(CN)_2(H_2O)_4][Co(ox)_2(en)]$
   iii. $[CU(NH_3)_2Cl_2]$
   iv. $[Cr(NH_3)_3(NC)_2(H_2O)]^+$
   v. $[Fe(CN)_6]^{4-}$

3. Explain optical isomerism in coordination compounds with an example.

1.2.3.3 Analytical Techniques

- Introduction to analytical chemistry (Scope: *definition and basic steps in analytical chemistry*).
- Thin Layer Chromatography (TLC) (Scope: *principle, R_f value, instrumentation and applications*).
- High Performance Liquid Chromatography (HPLC) (Scope: *principle, instrumentation-components of basic HPLC system and applications*).
- Spectroscopy (Scope: *mass spectrometry: principle, instrumentation, interpret mass spectrum, and applications, Infrared (IR) Spectroscopy: principle, instrumentation, interpret IR spectrum and applications, Nuclear magnetic resonance (NMR) spectroscopy: principle, equivalent and non-equivalent proton, chemical shift, spin-spin coupling, (n+1) rule, instrumentation, interpret NMR spectra of aliphatic hydrocarbons and applications*).

Learning Experiences:

Introduction to Analytical Chemistry

The teacher may use Cooperative Learning to deliver the lesson.

- The learner in team explores the definition and basic steps involved in analytical techniques.
- The learner designs a flow chart outlining the basic steps of analytical techniques and shares to the class.

Thin Layer Chromatography (TLC)

The teacher may use Research, Evidence and Inference (REI) to deliver the lesson.

- The learner in team explores the types and significance of analytical techniques in daily life.
- The learner in team shares the information to the class.

- The learner in team explores the working principle, instrumentation and use of thin layer chromatography.
- The learner in team plans how TLC can be applied in real life based on the scenario created by the teacher (*Refer Appendix 12(c) for sample scenario*).
- The learner in team shares their plans to the class for feedback and comment.
- The learner applies the knowledge of analytical techniques to investigate the presence of aromatic compounds in local plant extracts. (With the help of a teacher, publish it in the school journal/national journal/international journal).

High Performance Liquid Chromatography (HPLC)

The teacher may use Multimedia Approach to deliver the lesson.

- The learner uses the video link *https://www.youtube.com/watch?v=eCj0cRtJvJg&t=183s* to explore the working principle, instrumentation and applications of HPLC.
- Based on the information from the video, the learner explains the working principle, instrumentation and applications of HPLC using PowerPoint presentation to the class for feedback and comment.

Mass Spectroscopy (MS)

The teacher may use Multimedia Approach to deliver the lesson.

- The learner uses the video link *https://www.youtube.com/watch?v=EzvQzImBuq8* to explore the working principle of mass spectrometry.
- The learner in team explores the instrumentation and applications of mass spectrometry.
- The learner in team shares the information on instrumentation and applications of mass spectrometry to the class for feedback and comment.
- The learner interprets mass spectra of organic compounds based on the fragmentation pattern of a molecular ion and daughter ions.
- The learner determines the molecular mass of an organic molecule from its molecular ion peak in a mass spectrum.
- The learner submits the work to the teacher for feedback and comment.

Infrared Spectroscopy (IR Spectroscopy)

The teacher may use Multimedia Approach to deliver the lesson.

- The learner uses the video link *https://www.youtube.com/watch?v=0S_bt3JI150* to explore the working principle, instrumentation and use of IR spectroscopy.
- The learner in team explores the instrumentation and applications of IR spectrometry.
- The learner in team shares the information on instrumentation and applications of IR spectrometry to the class for feedback and comment.

- The learner interprets IR spectra of organic compound and identifies the functional groups present in the organic compound.
- The learner submits the work to the teacher for feedback and comment.

Nuclear Magnetic Spectroscopy (NMR Spectroscopy)

The teacher may use Multimedia Approach to deliver the lesson. The teacher provides worksheets on NMR spectra of aliphatic hydrocarbons.

- The learner uses the video link *https://www.youtube.com/watch?v=sfiQFQYgJuQ* to explore the working principle of NMR spectroscopy.
- The learner in team explores the instrumentation and applications of NMR spectroscopy using relevant sources.
- The learner in team presents the information on the instrumentation and applications of NMR spectroscopy using PowerPoint presentation.
- The learner in team explores concept of equivalent and non-equivalent proton, chemical shift, spin-spin coupling and (n+1) rule, and prepares the power notes.
- The learner interprets the NMR spectra of aliphatic hydrocarbons provided in the worksheet and submits to the teacher for feedback and comment.
- The learner analyses the importance of NMR in the medical field using relevant sources.
- The learner designs an experiment to conduct a chemical analysis of a sample of beverage available in the market.
- The learner interviews a forensic expert in JDWNRH or RBP headquarters or Pharmaceutical Institutes to explore the type of analytical technique used in investigating the crime. The learner may do contact or online interview with the expert.

Assessment:

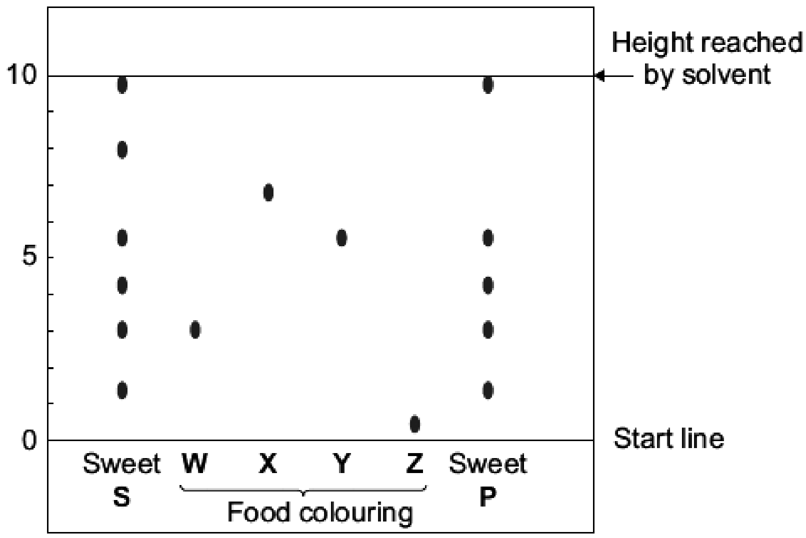
- The teacher may use assessment techniques such as question answer, DARTs, game, crossword puzzle, review, report writing, etc. to assess the learner's conceptual understanding of thin layer chromatography, high performance liquid chromatography, mass spectrometry, infrared spectroscopy and nuclear magnetic resonance spectroscopy.
- The teacher may assess the learner's skills in information management, collaboration, communication, presentation, interpretation, differentiation, investigation, analysis, and creation while designing and carrying an experiment, and exploring information on analytical techniques.
- The teacher may design rubric or checklist to assess the learner and accordingly provide necessary intervention.
- For recording and reporting, refer National School Curriculum Framework (NSCF-2021).

Resources:

- REC repository
- National School Curriculum Framework 2021
- Text book of chemistry Class XII (2017) S.Chand Publisher.
- *https://www.youtube.com/watch?v=qdmKGskCyh8*
- *https://www.youtube.com/watch?v=EzvQzImBuq8*
  https://www.youtube.com/watch?v=0S_bt3JI150
- *https://www.youtube.com/watch?v=sfiQFQYgJuQ*
- *https://www.youtube.com/watch?v=eCj0cRtJvJg&t=183s*

Challenge Your Thinking

1) Scientists say that some food colourings cause hyperactive behaviour in young children. The food colourings are added to cake and some sweets. W, X, Y and Z are food colourings that may be added in the sweets. Sonam used chromatography to investigate if two different samples of sweets S and P contain food colourings. The chromatogram is shown in the figure below.



With reference to the chromatogram, answer the following questions

(i) What are the food colourings present in S and P
(ii) Which food colouring has an Rf value of 0.7?
(iii) What conclusion can you draw about food colourings in S and P
(iv) How can you prevent using food colourings that are harmful?

2) Answer the following questions;

(i) What is Rf value?
(ii) Which chromatography technique is used for separation of amino acids?
(iii) Explain the principle used in HPLC.

2. APPENDICES

2.1 Weighting and Time Allocation

2.1.1 Class XI

Theme	Topic	Maximum Time Required (minutes)	Weighting (%)
Classifying Materials	Atomic Structure	864	12 %
	Chemical Bonding	864	12 %
Materials and Change	Introduction to Organic Chemistry	936	13 %
	Hydrocarbons	792	12 %
	Alcohols	432	6 %
	Aromatic Organic Compounds	576	7 %
Patterns in Chemistry	Periodic Table	792	11 %
	Oxidation Number	432	6 %
	Chemical Equilibria	792	11 %
	Phase Equilibria	720	10 %
Total		**7200**	**100 %**

2.1.2 Class XII

Theme	Topic	Maximum Time Required (minutes)	Weighting (%)
Classifying Materials	Acid-base Equilibria	648	9%
	Redox Equilibria	648	9%
	Nuclear Chemistry	360	5%
	Chemical Kinetics	504	7%
	Thermodynamics	504	7%
Materials and Change	Carbonyl Compounds	576	8%
	Carboxylic Acids	576	8%
	Carboxylic Acid Derivatives	720	10%
	Amines	360	5%
	Amino Acids	288	4%
Patterns in Chemistry	Colligative Properties	648	9%
	Coordination Chemistry	576	8%
	Analytical Chemistry	792	11%
Total		**7200**	**100%**

2.2 Sample Analogy for Orbit and Orbitals

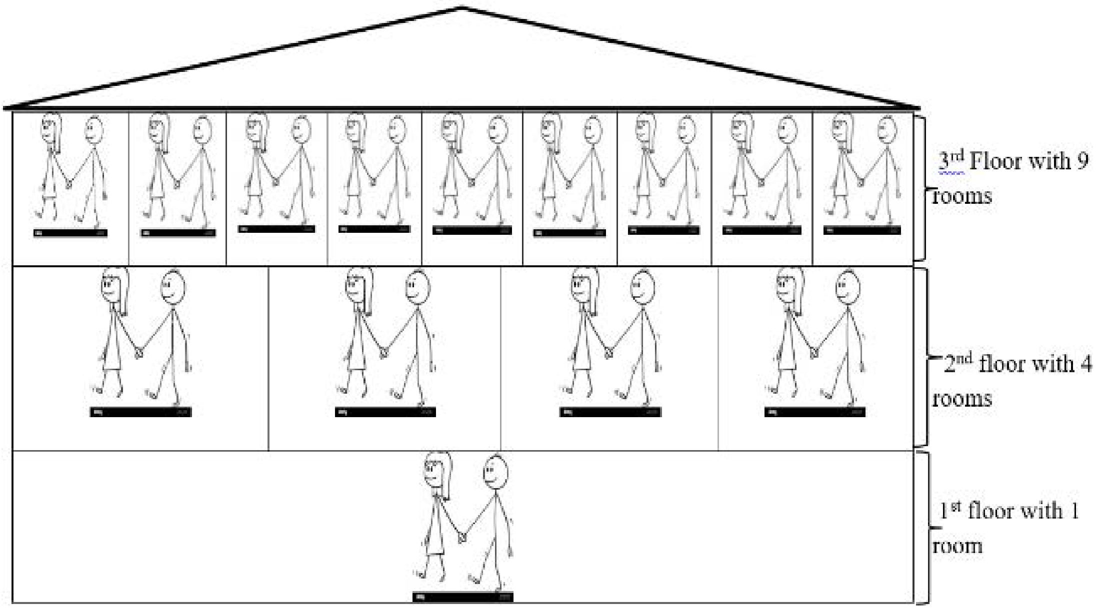


Fig. 1.1 Sample analogy of orbit and orbitals

Floor represents shell and numbers of rooms signify subshells and orbitals.

Male and female represents electrons with two different spins.

2.3 Appendix 11(b)

Phase change lab 1

Question:

If you heat a beaker of ice water until it is boiling, will the temperature change constantly or only at certain times?

Materials:

- Hot plate,
- thermometer,
- 500mL beaker,
- stirring rod,
- tongs, ice

Procedure:

1. Make a data table with two columns: one for (0 to 29 min.) the other for temperature (^{O} C)
2. Place in the beaker 100g of ice and 100 mL of cold water. Record your volume.
3. Put a thermometer in the beaker and wait for the temperature to stabilize.
4. Record temperature at time = 0 minutes.
5. Put the beaker on the hot plate. Turn the hot plate to 150 ^{O} C. Take turns in your group stirring gently and constantly.
6. Record the temperature every thirty seconds. Make a note next to the times at which the ice first melts, totally melts and at time when the water first boils.
7. Once the water has started to boil, record the temperature for 4 more minutes at 30 seconds intervals.
8. Using your tong, take the beakers off the hot plate and put it on a towel to cool, away from the edge of the lab bench and other students. Record your volume.
9. On graph paper, graph time (seconds) on the x-axis and temperature (^{O} C) on the y-axis. Connect the data points into a line to analyse what happened when the ice melted and water boiled. This is not a best-fit line.
10. Draw pictures of water's structure at the nanoscale when it was a solid, a liquid and a gas.

11. Describe the characteristics of a solid, a liquid and a gas. What determines if a substance is one or the other?
12. Define the following: system, surrounding, phase, component, melting point and boiling point.

Conclusion:

1. At what temperature did the ice melt? What temperature did it boil?
2. At what points on the graph did the temperature change? At what point did it stay the same?
3. What can you conclude about the temperature during a phase change based on the question 2?
4. What happens to the energy of the water as it changes from a solid to a liquid to gas
5. What was the difference between the starting and ending volume? What might account for the difference?
6. Write a conclusion for this experiment.
7. How close was your phase change diagram to theoretical phase change diagrams? If it was not close, what may have been the reason for this?

2.4 Appendix 11(c)

Phase change lab 2

Question:

Is it possible to add heat to a substance without the temperature of the substance increasing?

Materials

- Thermometer
- Hot plate
- Beaker (2), 150-mL or larger
- Measuring cylinder, 10-mL
- Test tube
- Test tube rack
- Stir rod
- Distilled water
- Crushed ice to fill the beaker
- NaCl

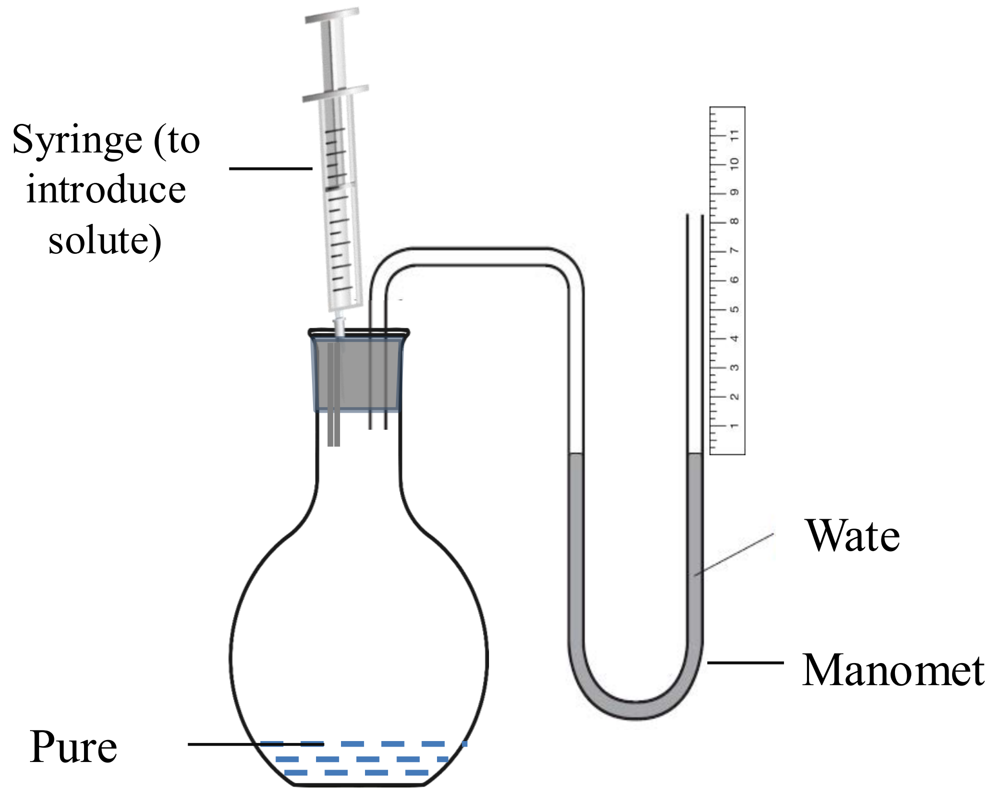
Procedure

1. Pour 3 mL of water in a test tube using the measuring cylinder
2. Record the initial temperature of water using the thermometer.
3. Take a beaker half-filled with ice.
4. Prepare a freezing mixture by adding two spatula of NaCl to the ice in the beaker and stir the mixture
5. Place the test tube containing 3 mL of water in the freezing mixture.
6. Add more ice and NaCl to the freezing mixture.
7. Record the temperature every 2 minutes till water in the test tube freezes.
8. Stop recording temperature when the temperature of the freezing mixture falls to -6.0 ˚C or cooler.
9. Take out the test tube from the freezing mixture and place it in a beaker containing 100 mL of water.
10. Heat the beaker until the water boils.
11. Record the temperature in the test tube when the ice starts melting.
12. Continue recording the temperature every 2 minutes until water in the test tube boils.
13. Plot a graph of Temperature (˚C) versus Time (s) for freezing of water, melting of ice and boiling of water.

Conclusion

1. Relate the shape of your graphs above to the behavior of the water molecules. Hint: Explain whether the heat added caused the molecules to move faster or break attractions.
2. Explain how it is possible to add heat to a substance without the temperature of the substance increasing.
3. According to your lab results, what is the melting point and boiling point of distilled water? Compare your result with the result of other teams.
4. Explain how heat and temperature are different.
5. Explain phase change in the system and draw phase diagram based on the data obtained.

2.5 Appendix 11(d)



2.6 Appendix 12 (a)

Worksheet on Nomenclature and Preparation of Carbonyl Compounds

1. Complete the following table.

Formula	Common name	IUPAC name
HCHO		
CH_3CHO		
C_6H_5CHO		

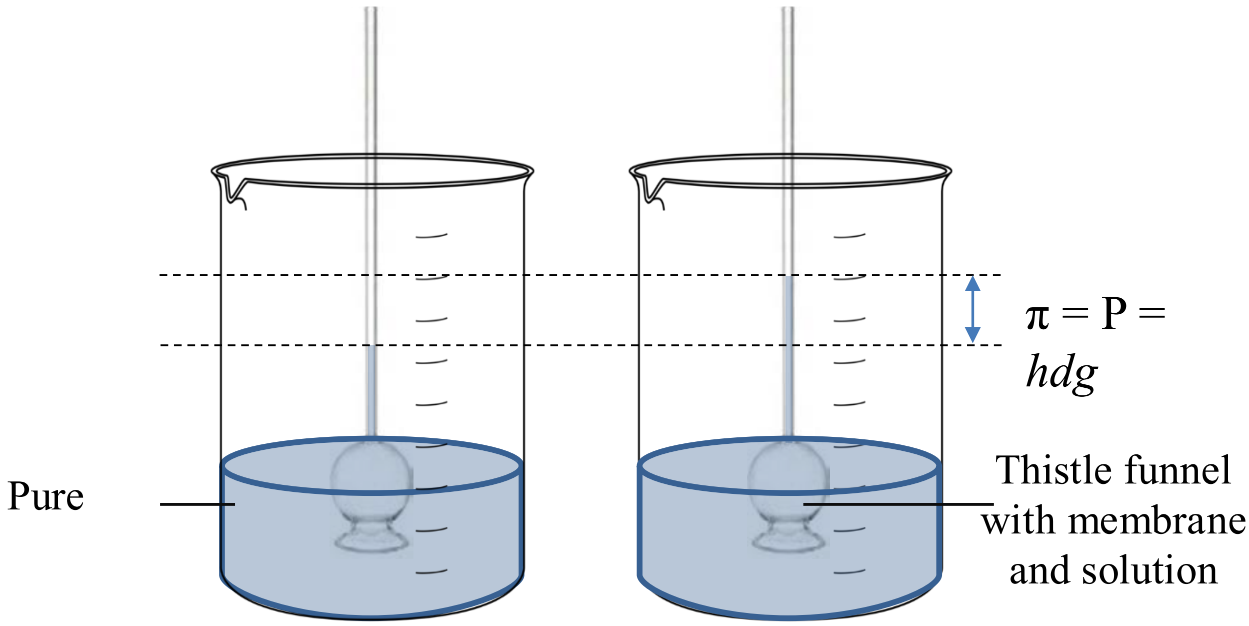
2. Complete the following chemical reaction.

i. $2CH_3OH + O_2 \longrightarrow$ ……………………..

ii. $C_6H_5CH_3 + 2CrO_2Cl_2 \xrightarrow{CCl_4}$ ……………………..

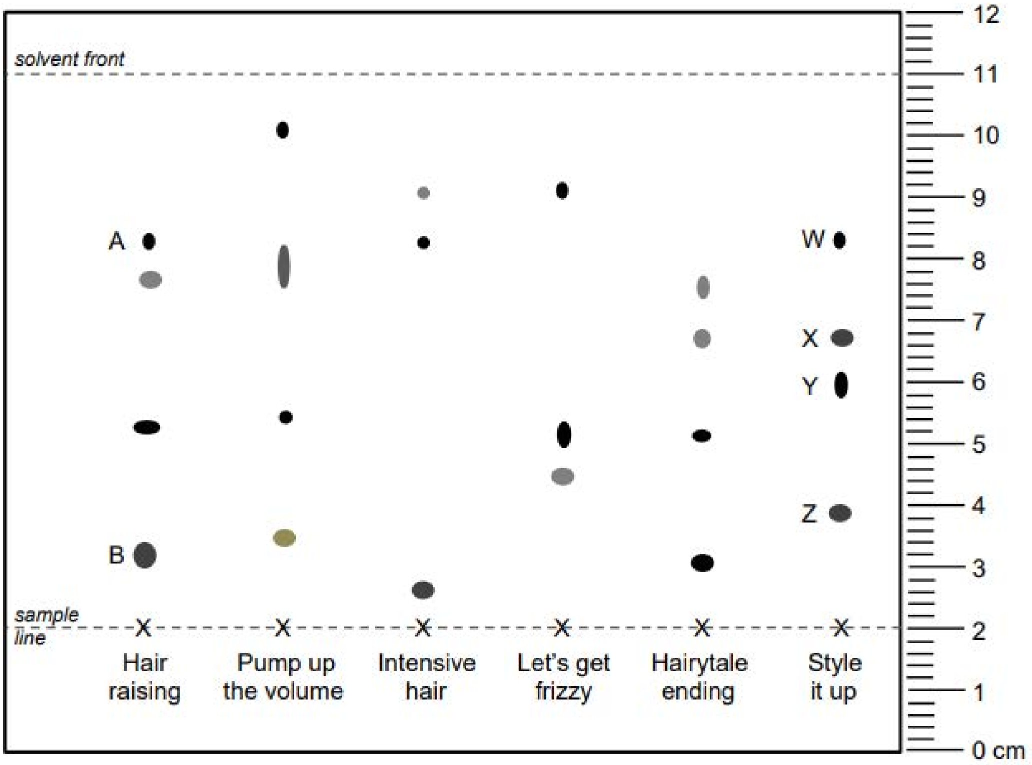
2.7 Appendix 12(b)

Osmotic Pressure



2.8 Appendix 12(c)

Analysis of various hair products such as dyes, sprays and serums can be of great benefit to forensic investigators. Since hair samples are often found at crime scenes, identification of the hair products which are coated on the hair can provide valuable information to investigators. One common and effective method used for the analysis of hair products is thin layer chromatography (TLC). The TLC plate below shows the analysis of six (6) different popular brands of hair spray.



Scenario

A police officer found a hair sample from a crime scene and suspected it to be of a woman. After investigation, the police officer had three women as suspects. How would you as a forensic investigator solve the crime using the above information from TLC?