National School Curriculum

INSTRUCTIONAL GUIDE FOR CHEMISTRY

CLASSES IX & X

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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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).

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1. CURRICULUM CONTENT

1.1 Curriculum Content (Class IX)

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 chemical bond which determines the properties of materials.

Competencies

- Relate chemical bonding to the properties and usefulness of materials in day-to-day life.

  Objective(s):

  Chemical Bond

  i. Explore the information on definition of chemical bond, types of chemical bond, and duplet and octet rule using relevant sources.
  ii. Explain the formation of ionic and covalent bond using simulation.
  iii. Explain the formation of ionic, covalent and coordinate bond using simulation.
  iv. Construct 2D/3D models that explains ionic bond and covalent in relation to duplet and octet rule.
  v. Investigate the properties of materials based on types of chemical bonds and their applications.
  vi. Design a device which uses covalent or ionic materials to relate the bonding with the properties of materials.
  vii. Research to relate the significance of chemical bonding in the biological system and existence of life on earth.

1.1.1.1 Chemical Bond

- Chemical Bond: (*Scope**:** Definition, types of chemical bond, and formation of cation and anion).*
- Duplet and Octet rule: *(Scope: explanation with examples).*
- Ionic bond: (*Scope: definition of ionic bond, formation of ionic bonds with examples, general properties of ionic compounds*)
- Covalent bond: (*Scope: definition of covalent bond, types of covalent bond, formation of covalent bond and coordinate bond with examples, general properties of covalent compounds*).
- Properties of materials based on bonding and the application of materials based on the properties.

Learning Experiences:

The teacher may use blended learning (*Refer Appendix 9(g) for sample*) to deliver the lesson. The teacher uploads the reading material on chemical bond along with the instruction for the learner, one or two days before the lesson.

- The learner explores the information on chemical bond before the lesson using the material uploaded in Google Classroom or any other learning platform.

- The learner notes down the definition of chemical bond, types of chemical bond and the properties of covalent and ionic compounds before the lesson.
- The learner works in a team to discuss and prepare a PowerPoint Presentation on definition of chemical bond, types of bond and properties under the guidance of the teacher. The presentation includes models and simulation on the formation of ionic and covalent bond.
- A member from each team presents the work to the class
- The learner in a team designs a device that may have local application using the properties of chemical substance
- The learner in a team designs a device that may have local application based on the knowledge of ionic or covalent substance (Example: designing a cell that uses ionic or covalent substance).
- The learner in team writes chemistry behind the working of the device designed in a team.
- The team shares the design of the device in the class.
- As a follow-up activity, the learner carries out research on the significance of chemical bonding in biological system and existence of life on earth.
- The learner shares the findings to the class using different media.

Assessment:

- The teacher may use assessment techniques such as question answer, DARTs (*Refer Appendix 9(c) for sample*), game, crossword puzzle (*Refer Appendix 9(e) for sample*), review, report writing, etc. to assess the learner's conceptual understanding of chemical bond.
- The teacher may assess the learner's skills in collaboration, presentation, information management, communication, differentiation and creation while exploring information, preparing PowerPoint presentation and designing a device by observing learners as they explore information and carry out the assigned task on the chemical bonds, type of chemical bonds with relevant examples, and the characteristics of ionic and covalent compounds.
- The teacher may design assessment tools such as rubric, checklist or rating scale to assess the learner and accordingly provide necessary intervention.
- The teacher may assess the learner's scientific values and attitudes such as curiosity, intellectual honesty, perseverance, etc.
- For recording and reporting refer National School Curriculum Framework (NSCF-2021)

Resources:

- REC Repository
- A Text book of Chemistry Class IX (2017), Macmillan Publishers
- National School Curriculum Framework (NSCF-2021)

Challenge Your Thinking

1. The table below shows the information on certain chemical compounds.

Compound	Physical state at room temp.	Melting point (°C)	Solubility in water	Conductivity
A	Gas	-182.5	Insoluble	Non-conductor
B	Solid	801	Soluble	Conductor
C	Liquid	-2.92	Insoluble	Non-conductor
D	Solid	334	Soluble	Conductor

Use the information from the table and answer the following questions.

(i) Which compound has the highest melting point?
(ii) Which substances are ionic and which are covalent? Explain your answer.
(iii) Why does substance A conduct electricity in water whereas substance B does not?
(iv) Give an example each of substance A and substance B.

2. An element X with an atomic number 9 forms the bond with an element Y with atomics number 17.
(v) Write the electronic configuration of X and Y
(vi) Predict the type of bond that may be formed between X and Y.
(vii) Illustrate the formation of bond with electron dot cross diagram.
(viii) Mention one real life significance of the bond.

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 organic chemistry, activity series of metals and green chemistry.

Competencies

- Outline the fundamentals of hydrocarbons and polymers in terms of synthesis, properties and applications to analyze their impact on health, environment and society.

Objective(s)
Organic Chemistry

i. Explore the definition of organic compounds, reasons for existence of a large number of organic compounds, their sources and importance using relevant sources.
ii. Explain classification, functional group, nomenclature and homologous series of hydrocarbons through relevant sources.
iii. Explain isomerism in hydrocarbons using simulations.
iv. Explore the information on physical and chemical properties of methane, ethane, ethene and ethyne using relevant resources.
v. Design an experiment to investigate the difference between saturated and unsaturated hydrocarbons.

vi. Compare the efficiency of saturated and unsaturated hydrocarbons as a fuel in automobiles.
vii. Explain monomers, polymers and polymerization by analysing the given information on polymers.
viii. Explore on natural and synthetic polymers using relevant sources.
ix. Explain the formation of polyethene and PVC using simulation.
x. Apply the knowledge of hydrocarbons and polymerization to design physical or computer models of any polymer that may have commercial values.
xi. Evaluate the impacts of synthetic polymer on health, environment and society.
xii. Research on alternative polymers that can reduce the environmental impact caused by synthetic polymers.

- Relate the properties of metals with reference to metal activity series for identifying metals used for different purposes.

Objective(s)
Activity Series of Metals

i. Locate elements which are metals, metalloids and non-metals based on their characteristic properties using the periodic table.
ii. Construct activity series of metals based on their reactivity.
iii. Predict the reaction of metals with air, water and acids using reactivity series of metals.
iv. Explain the uses of metal activity series after exploring the information through relevant sources.
v. Apply the knowledge of metal activity series to design a chemical process to extract a metal from its compound.
vi. Apply the knowledge of activity series of metals for selecting different types of metals to design medals for the school athletes.
vii. Explain the chemistry behind why some metals are more reactive than others.

- Appreciate the bio-geochemical cycles to adopt green practices to reduce the impact on health, society and environment.

Objective(s):
Green Chemistry

i) Explore the principles of green chemistry in relation to design and process of goods that reduce or eliminate generation of hazardous substances.
ii) Explain the nitrogen cycle using simulation or a model.
iii) Compare chemical fertilizers and bio fertilizers based on their environmental consequences.
iv) Explain carbon cycle using simulation or a model. Explain the significance and impact of greenhouse gases.
v) Explain global warming using simulation or a model.

vi) Apply the principles of green chemistry to design a Bhutanese house that can keep us warm in winter.
vii) Research to find out how Bhutan may prepare for the impact of global warming and climate change.
viii) Explore the adoption of green technologies to reduce the impact on environment due to greenhouse gases.

1.1.2.1 Organic Chemistry (Hydrocarbons)

- Organic Compounds: (*Scope: definition, reasons for existence of large number of organic compounds, sources and importance of organic compounds*)
- Hydrocarbons: (*Scope: definition, classification of hydrocarbons, alkyl group, functional group, homologous series, and nomenclature of hydrocarbons*).
    - Alkanes: (*Scope: definition with examples, isomerism in alkanes, methane and ethane: physical and chemical properties (combustion, oxidation, substitution reactions), and uses*).
    - Alkenes: (*Scope: definition with examples, isomerism in alkenes, ethene: physical and chemical properties (combustion, oxidation, addition reactions), and uses*).
    - Alkynes: (*Scope: definition with examples, isomerism in alkynes, ethyne: physical and chemical properties (combustion, oxidation, addition reactions), and uses*).
- Polymers: (*Scope: monomers, polymers, polymerization, natural and synthetic polymers, uses, and impacts*).

Learning Experiences:

Organic Compounds

The teacher may use flipped - classroom to deliver the lesson. The teacher uploads the reading material on definition of organic compounds, reasons for existence of a large number of organic compounds, their sources and importance along with the instruction for the learner. The material is uploaded in Google Classroom or other learning platform one or two days before the lesson.

- The learner explores the information from the uploaded material before the lesson.
- The learner notes down the meaning of organic compounds, reasons for existence of a large number of organic compounds, their sources and importance before the lesson.
- The learner carries out fishbowl activity/mix-pair-share to discuss the meaning of organic compounds, reasons for existence of a large number of organic compounds, their sources and importance.

Hydrocarbons

The teacher may use backward design to deliver this lesson.

Identify the desired goals

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

- Classification of hydrocarbon, functional group, nomenclature, homologous series and isomerism in hydrocarbons.
- The variation in physical properties based on carbon chain.

- Explain the chemical properties of hydrocarbon in reference to combustion, oxidation, substitution and addition.
- Differentiate between saturated and unsaturated hydrocarbons.
- Compare the efficiency of saturated and unsaturated hydrocarbons as a fuel.

Determine acceptable evidence

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

Plan learning experiences

- The learner explores the information on classification of hydrocarbon, functional group, nomenclature, homologous series and isomerism in hydrocarbons using the material provided by the teacher/ relevant resources.
- The learner plots a graph using the data provided for hydrocarbons in each homologues series to determine the variation in the physical properties.
- The learner completes the chemical equations related to chemical properties of hydrocarbons.
- The learner designs an experiment and carry out the investigation to differentiate saturated and unsaturated hydrocarbons.
- The learner interprets the values of octane number of saturated and unsaturated hydrocarbons provided by the teacher to compare the efficiency as a fuel.

Polymer

The teacher may use backward design to deliver this lesson.

Identify the desired goals

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

- Classification of polymers into natural and synthetic
- Information on monomers. Polymers, polymerization.
- Explain the formation of polyethene and PVC using simulation.

Determine acceptable evidence

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

Plan learning experiences

- The learner explores the information on classification of polymers into natural and synthetic polymers using relevant resources.
- The learner explores the information on monomers, polymers, and polymerization.
- The learner design 3D model/simulation to show the formation of polyethene and PVC.

Impact 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 - pollution caused by plastic bags, polyethene bags, packaged food wrappers, etc.

Generate ideas to solve the problem

- The learner explores the basic concept of monomers, polymers and polymerization with reference to polyethene and polyvinyl chloride (PVC). The learner may use simulation to explain the formation of polyethene and PVC.
- The learner uses the link (*https://www.youtube.com/watch?v=RS7IzU2VJIQ*) to find out the impacts of synthetic polymers on health, environment and society.
- The learner works in team to research on alternative polymers which might have less impact on environment.

Action

- Considering the less impact on environment, 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 through various media

Evaluation

- The learner evaluates the model of the polymer based on feedback from the audience.

Assessment:

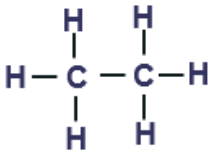
- The teacher may use assessment techniques such as question answer, DARTs, game, crossword puzzle, review, report writing, etc. to assess the learner's conceptual understanding of organic compounds, hydrocarbons, and polymers.
- The teacher may assess the learner's skills in collaboration, presentation, information management, communication, differentiation, analysis, data interpretation, investigation and creation while exploring information on the concept organic compounds, hydrocarbons, and polymers, designing a model of polymer and designing an experiment
- The teacher may design assessment tools such as rubric, checklist (*Refer Appendix 9(f) for sample*) or rating scale to assess the learner and accordingly provide necessary intervention.
- The teacher may assess the learner's scientific values and attitudes such as curiosity, intellectual honesty, perseverance, etc.
- For recording and reporting refer National School Curriculum Framework (NSCF-2021)

Resources:

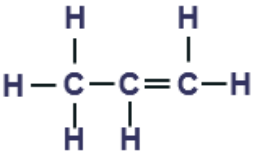
- REC Repository
- A Text book of Chemistry Class IX (2017), Macmillan Publishers
- National School Curriculum Framework (NSCF-2021)
- Impact of polymers link: *http://www.youtube.com/watch?v=RS7IzU2VJIQ*

Challenge Your Thinking

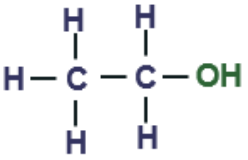
1. The structures of some organic compounds are shown below. Study the structures and answer the questions that follow.



A



B



C

D

(i) Which compound is a saturated hydrocarbon? Explain your answer.
(ii) Which two compounds are unsaturated hydrocarbons? Explain your answer.
(iii) Which compound is not a saturated hydrocarbon? Why?
(iv) Unsaturated hydrocarbons are less efficient than saturated hydrocarbons as fuel. Give reasons.

2. Each year in Bhutan, thousands of plastic bags are given free to shoppers. These bags are made from a polymer called polyethene.
(v) What is a polymer?
(vi) What is the monomer unit of polythene?
(vii) Why is polythene bio undegradable?
(viii) Discuss the advantages and disadvantages of using polythene bags.

1.1.2.2 Reactivity of Metals

- Reactivity of Metals: (*Scope**:** definition of metals, nom-metals, and metalloids with examples, physical and chemical properties of metals and non-metals).*
- Activity Series of Metals *(Scope: definition of activity series of metals, reaction of metals such as Na, Ca, Mg, Zn, Fe, Pb and Cu with air, water and acids, and application of reactivity series of metals).*

Learning Experiences:

The teacher may use 5E method to deliver the lesson. The teacher provides interactive video tutorials using software such as Camtasia, TED-Ed, and Flashback on the reactivity series of metals, reaction of metals with air, water and acids, and uses of reactivity series of metals through Google Classroom or any other learning platform. The teacher may refer the link for the sample of TED-Ed (*https://ed.ted.com/on/B2CGWugj*).

Question: Why does sodium react with water whereas copper does not?

Engage

- The learner uses the periodic table to locate the position of metals, non-metals and metalloids.
- The learner uses the materials on reactivity series of metals provided by the teacher and engages in discussion to find out why sodium is more reactive than copper.

Explore

- The learner designs the experiment and investigates to find out the reactivity of different metals such as sodium, calcium, magnesium, zinc, iron, copper and lead with water.

Explain

- The learner explains the difference in reactivity of the above metals with water.

Extend

- The learner predicts the reactivity of metals with air, water and acids.
- Based on the prediction, the learner constructs metal activity series.
- The learner designs a chemical process to extract a metal from its compound using the knowledge of metal reactivity series.
- The learner designs a process for selecting different types of metals to design medals for the school athletes.
- The learner researches on the impact on economy due to corrosion of metals.

Evaluate

- The learner is evaluated on construction of metal activity series and designing of the chemical processes

Assessment:

- The teacher may use assessment techniques such as question answer, DARTs, game (*Refer Appendix 9(d) for sample*), crossword puzzle, review, report writing, etc. to assess the learner's conceptual understanding of metal reactivity series.
- The teacher may assess the learner's skills in collaboration, information management, communication, differentiation, analysis, investigation and creation while exploring information, designing skill on the concept of metal reactivity series.
- The teacher may design assessment tools such as rubric, checklist or rating scale to assess the learner and accordingly provide necessary intervention.
- The teacher may assess the learner's scientific values and attitudes such as curiosity, intellectual honesty, perseverance, etc.
- For recording and reporting refer National School Curriculum Framework (NSCF-2021)

Resources:

- REC Repository
- A Text book of Chemistry Class IX (2017), Macmillan Publishers
- National School Curriculum Framework (NSCF-2021)
- TED-Ed link: *https://ed.ted.com/on/B2CGWugj*

Challenge Your Thinking

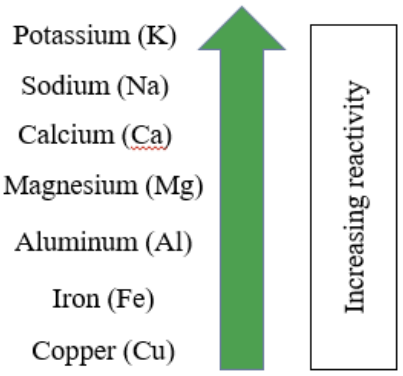
1. A student conducted an experiment using the following method.
   - Pour some copper sulphate solution into a beaker and record the temperature of the solution.
   - Add a known mass of magnesium and stir.
   - Record the maximum temperature of the mixture.
   - Repeat the experiment with silver, iron, gold and zinc.

   The result of the experiment is shown in the table below.

Metal	Temperature Change (^{0}C)		Average Temp. (^{0}C)
	Experiment 1	Experiment 2	
Mg	11.5	16.5	14.0
Ag	0.0	0.	0.0
Fe	3.0	4.0	3.5
Au	0.0	0.	0.0
Zn	70	8.0	7.5

   (i) Mention two factors which should be kept constant in the experiment.
   (ii) State and explain which metals gave the least reliable temperature rise.
   (iii) State and explain which metal used in the experiment is the most reactive.
   (iv) There is no temperature rise when silver is added to copper sulphate solution. Explain.
   (v) Why do the results make it impossible to decide which of the metals is least reactive?
   (vi) Write a balanced displacement reaction between zinc and copper sulphate solution.

2. A reactivity series of some metals is shown below. Refer the series and answer the questions that follow.



   a. Silver does not appear on the above reactivity series. Copper will react with silver nitrate solution to form silver.
      (i) Write a balanced chemical equation for the reaction of copper with silver nitrate solution.
      (ii) Indicate the position of silver on the above reactivity series.
      (iii) Silver nitrate solution is colourless. What is the colour of solution at the end of the experiment?
      (iv) Explain why copper displaces silver from silver nitrate solution?

b. Some of the metals in the above series react with acid.
   (i) Why are metal reactions with acid described as exothermic?
   (ii) Identify the independent, dependent and controlled variables in reactions of different metals.
   (iii) Give one property that a metal should have in order to make hot water pipe.
   (iv) Give one property that a metal should have in order to make food can.

1.1.2.3 Green Chemistry

- Concept of Green Chemistry: (*Scope**:** concept, principles and practices of green chemistry*).
- Nitrogen Cycle: (*Scope: description of nitrogen cycle, importance of converting nitrogen to ammonia for agriculture*).
- Fertilizers: (*Scope: sources of fertilizers with examples, uses of fertilizers, environmental consequences of excessive use of fertilizers*).
- Carbon Cycle: (*Scope: description of carbon cycle, importance and consequence of disturbance to carbon cycle*).
- Global Warming: (*Scope: greenhouse gases and their importance, explanation of global warming, natural and man-made causes of global warming, effect of global warming, mitigation towards cause of global warming, carbon sequestration*).

Learning Experiences:

Principles of Green Chemistry, Nitrogen Cycle, Carbon Cycle and Global Warming

The teacher may use cooperative learning to deliver the lesson. The teacher divides the class into four different teams and assigns a topic to each team.

- The learner in team may be provided with any one of the following topics: principles of green chemistry, nitrogen cycle, carbon cycle, and their significance, greenhouse gases, global warming in terms of causes, effects, mitigation and carbon sequestration.
- The learner in team works on the assigned topic and prepares a presentation. The presentation should include models, videos, or simulations.
- The team shares the presentation in Google Classroom or any other learning platform for feedback and comment from the teacher and classmates.
- The team incorporates the feedback to prepare the presentation for the class.
- The learner in team makes the presentation to the class.
- The learner designs a Bhutanese house applying the principle of green chemistry and energy efficiency. The learner may write down the type of material used for the design and essential features of the house.
- The learner advertises the design through social media.
- The learner explores the information to suggest measures on how Bhutan may prepare for the consequences of global warming and climate change.
- The learner shares the work in Google Classroom or any other learning platform for feedback and comment from the teacher and classmates.

Fertilizers

The teacher may organise field trip to deliver the lesson. The teacher and the learner should follow the protocols of field trip.

- The learner visits nearby farm or RNR centre to interview and collect the information on the use of chemical and bio-fertilizers in relation to agricultural productivity and environmental pollution.
- Based on the interview, the learner analyses advantages and disadvantages of chemical and bio-fertilizers.
- Using the analysis report, the learner suggests measures to discourage the use of chemical fertilizers.

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 principles of green chemistry, carbon cycle, nitrogen cycle, fertilizers and global warming.
- The learner may assess the learner's skills in collaboration, information management, communication, differentiation, analysis, investigation, and creation while exploring the information, designing a model and making presentation to the class on green chemistry, carbon cycle, nitrogen cycle, fertilizers and global warming.
- The teacher may design assessment tools such as rubric, checklist or rating scale to assess the learner and accordingly provide necessary intervention.
- The teacher may assess the learner's scientific values and attitudes such as curiosity, intellectual honesty, perseverance, etc.
- For recording and reporting refer National School Curriculum Framework (NSCF-2021)

Resources:

- REC Repository
- A Text book of Chemistry Class IX (2017), Macmillan Publishers
- National Science Curriculum Framework (NSCF-2021)
- Video Link:
    - Nitrogen cycle: *https://www.youtube.com/watch?v=LbBgPekjiyc&t=3s*,
    - Carbon cycle: *https://www.youtube.com/watch?v=fcna9slTljs*,
    - Global warming: *https://www.youtube.com/watch?v=oJAbATJCugs* or *https://www.youtube.com/watch?v=PqxMzKLYrZ4&t=21s*)

Challenge Your Thinking

1. (a) A student carries out an experiment to synthesize polythene from ethene. Polythene is widely used polymer. Use the principles of green chemistry to make polythene less hazardous to the environment.

   (b) In a laboratory, students prepare aspirin from salicylic acid and acetic anhydride. One group of student uses water bath and the other group uses microwave oven to heat the reactants. Justify which group is practicing the principles of green chemistry while carrying out the experiment.

2. What is climate change? Is it different from global warming?

1.1.3 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 periodic table and chemical reactions and energy transfer.

Competencies:

- Apply the knowledge of periodic table to study and predict the properties, uses and position of new elements.

  Objective(s):
  Periodic Table

  i. Explain the variation in the periodic trends across the period and down the group and main features of modern periodic table.
  ii. Discuss the advantages and limitations of modern periodic table.
  iii. Create interactive periodic table for the first 20 elements.
  iv. Study the reaction of group 1 elements with oxygen and water.
  v. Explore the information on the noble gases and their uses.

- Relate the concept of chemical reactions to understand the fundamentals of energy changes, industrial applications and the material change.

  Objective(s):
  Chemical Reactions and Energy Transfer

  i. Discuss the significance and limitations of a chemical equation in relation to chemical reaction.
  ii. Balance chemical equation using different methods.
  iii. Design and carry out an experiment to explain the law of conservation of mass.
  iv. Design and carry out an experiment to explain the rate of reaction in terms of change in mass of reactants or products.
  v. Deduce the mathematical expression and unit for rate of reaction based on the above experiment and solve the numerical problems.
  vi. Explain the factors that affect the rate of the chemical reaction by exploring the information through relevant sources.
  vii. Relate collision theory with the rate of reaction.
  viii. Design a chemical process for a pharmaceutical company to optimize the yield of the medicines.
  ix. Design and carry out an experiment to identify exothermic and endothermic reactions.
  x. Interpret the graphs to explain exothermic and endothermic reactions.
  xi. Use the principles of exothermic and endothermic reactions to design a physical model of a hot or cold pack.

1.1.3.1 Periodic Table

- Modern Periodic Table: (*Scope**:** Characteristics of periods and groups, advantages and disadvantages of modern periodic table, and short description of the modern periodic table*).
- Trends in the Modern Periodic Table: (*Scope: Periodicity and causes of periodicity, valence electrons, atomic size, metallic character, ionization enthalpy, electron affinity, and electronegativity*).
- Group 1 Elements: (*Scope: Introduction, electronic configuration, and reaction with oxygen and water*).
- Group 18 Elements: (*Scope: Introduction, electronic configuration and uses*).

Learning Experiences:

Periodic Table: Feature, trend, advantages, limitations and group 1 elements.

The teacher may use Process Oriented Guided Inquiry Learning (POGIL) to deliver the lesson (*Refer Appendix 9(b) and 9(h) for sample*).

- The learner studies the interactive periodic table (*https://ptable.com/#Properties*) to explain the main features of the modern periodic table.
- The learner uses the interactive periodic table and follows the instruction provided by the teacher to explain the periodic trends.
- Based on the above information, the learner in team discusses the advantages and limitations of modern periodic table.
- The learner creates an interactive periodic table to address the limitation of the modern periodic table and present the interactive periodic table to the class.
- The learner completes the worksheet (*Refer Appendix 9(b) for sample*) provided by the teacher to study the reaction of alkali metals with water and oxygen.

Noble Gases: Introduction, electronic configuration and uses.

The teacher may use gallery walk to deliver the lesson.

- The learner in team works on topics provided and designs visual cards to display in the class.
- The learner in team visits and takes down note from visual display.
- The learner in team completes the worksheet (*Refer Appendix 9(i) for sample*) provided by the teacher.
- The learner submits the worksheet for feedback and comments.

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 main features of modern periodic table, periodic trends, limitations of modern periodic table and the reaction of alkali metals with water and oxygen.
- The teacher may assess the learner's skills in collaboration, information management, communication, differentiation, analysis, design and creation while exploring the information, creating an interactive periodic table and making presentation to the class on modern periodic table.

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

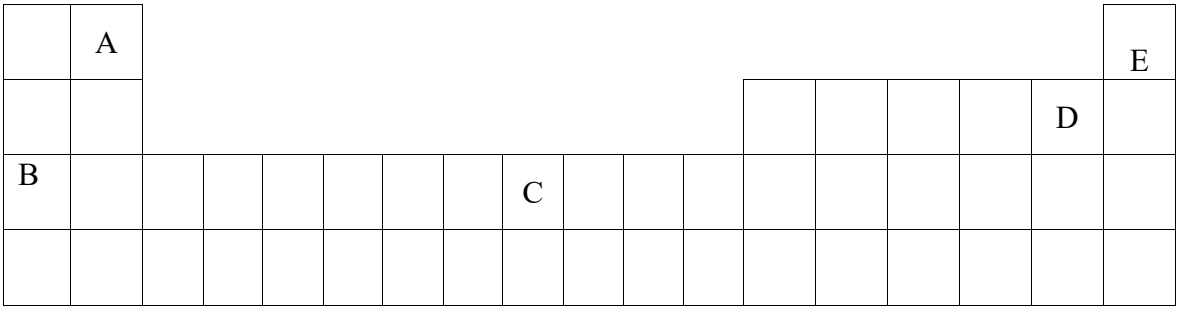
Resources:

- REC Repository
- A Text book of Chemistry Class IX (2017), Macmillan Publishers
- National School Curriculum Framework (NSCF-2021)
- Interactive periodic table link: *https://ptable.com/#Properties*
- POGIL sample (Appendix 9(b)).
- Noble gases online quiz link: *https://forms.gle/aixhA7nCfTQ1bKKv7*

Challenge Your Thinking

1. Arrangement of elements by atomic weights provided Mendeleev with some elements that didn't fit the patterns such as Argon. Explain how this problem was eventually overcome?

2. The periodic table below shows five different elements as A, B, C, D and E. Use the correct letter to answer the questions that follow.



(i) Which element is a transition metal?
(ii) Which element is in group 2?
(iii) Which element is a noble gas?
(iv) Which element has an atomic number 4?
(v) Which element forms only +1 ions?

1.1.3.2 Chemical Reactions and Energy Transfer

- Chemical Reactions and Energy Transfer: (*Scope**:** Steps for balancing the chemical equation, law of conservation of mass, significance of chemical equation, limitation of chemical equation, slow and fast reaction with examples, collision theory, rate of a chemical reaction in terms of change in mass of reactant or product factors affecting rate of chemical reaction, thermochemical reaction, definition of exothermic and endothermic reactions with examples and graphs*).

Learning Experiences:

Chemical Reaction, Chemical Equation and Rate of Reaction:

Teacher may use Inquiry Based Learning (IBL) to deliver the lesson. The teacher arranges four work stations (W1, W2, W3, and W4) along with instructions for each station. W1 may have vinegar and baking powder, W2 may have chalk powder and lime, W3 may have magnesium ribbon and spirit lamp, and W4 may have zinc granules and dilute HCl.

- The learner in team visits each work station to carry out the investigation as per the instruction provided.
- The learner records the observation. The learner engages in discussion with class about the observation and draws the generalization.
- The learner writes word equations for any two observations made in the work station.
- The learner translates the word equations into balanced chemical equations.
- The learner in team discusses the significance and the limitations of chemical equation.
- The learner shares significance and the limitations to the class.
- The learner designs and carry out an experiment to explain the law of conservation of mass.

Rate of chemical reaction

- The learner designs and carries out an experiment (*Refer Appendix 9(j) for sample*) to deduce mathematical expression for the rate of reaction in terms of change in mass of reactant and product.
- The learner uses the worksheet (*Refer Appendix 9(k) for sample*) to solve the numerical problems based on the above derivation.
- The learner in team designs an experiment to study the factors that affect the rate of reaction.
- The learner in team carries out the investigation to measure rate of reaction involving any two factors.
- The learner records the observation and interprets the data accordingly.
- The learner in team shares the findings to the class.
- The learner explores and correlates the rate of reaction to collision theory.
- Based on the knowledge of chemical reaction, the learner suggests a chemical process for a pharmaceutical company to optimize the yield of the pharmaceutical product.
- The learner shares their suggestion in the class.

Energy Transfer:

The teacher may use Predict-Observe-Explain (POE) to deliver the lesson. The teacher arranges two work stations (W1 and W2) along with instructions and worksheet for each station. W1 may have sodium hydroxide, beaker of water, and a thermometer and W2 may have ammonium chloride, beaker of water and a thermometer. The worksheet should have space for prediction, investigation and observation, and explanation.

- The learner in team visits the work station and carries out the activity based on the instruction provided and completes the worksheet (*Refer Appendix 9(l) for sample*) to study exothermic and endothermic reactions.
- The learner in team shares the completed worksheet to the class with thermochemical equation.
- The learner studies two types of graphs to distinguish exothermic and endothermic reactions.
- The learner explores other day-to-day life examples of exothermic and endothermic reactions.
- The learner in team designs a hot or cold pack using the knowledge of exothermic and endothermic reactions.
- The learner shares the design in the Google Classroom or any other learning platform.

Assessment:

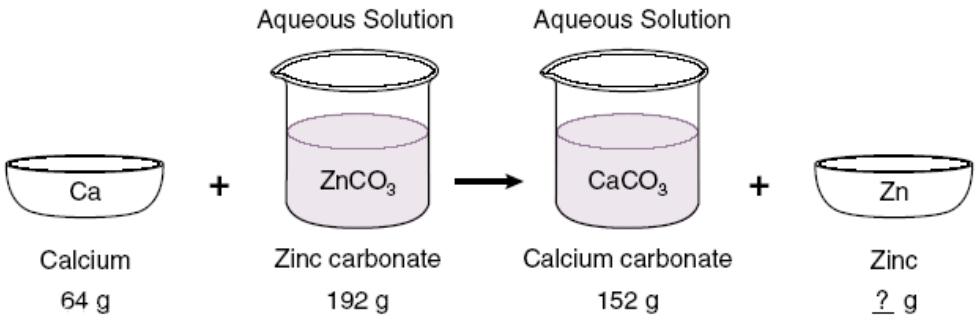
- The teacher may use assessment techniques such as question answer technique, DARTs, game, crossword puzzle, review, report writing, etc. to assess the learner's conceptual understanding of chemical reaction, rate of reaction, factors affecting rate of reaction and energy transfer.
- The teacher may assess the learner's skills in collaboration, information management, communication, differentiation, design, interpretation, and creation while designing the hand-warmer, designing a chemical process, and exploring the information on chemical reaction, rate of reaction, factors affecting rate of reaction and energy transfer.
- The teacher may design assessment tools such as rubric, checklist or rating scale to assess the learner and accordingly provide necessary intervention.
- The teacher may assess the learner's scientific values and attitudes such as curiosity, intellectual honesty, perseverance, etc.
- For recording and reporting refer National School Curriculum Framework (NSCF-2021)

Resources:

- REC Repository
- A Text book of Chemistry Class IX (2017), Macmillan Publishers
- National School Curriculum Framework (NSCF-2021)
- Video
    - Collision Theory: *https://www.youtube.com/watch?v=LJ5V522kO60&list=RDCMUCxAGrWOJ0dH3GRiynFxLWBg&start_radio=1&t=106*
- Simulation:
    - Balancing equations: *https://phet.colorado.edu/sims/html/balancing-chemical-equations/latest/balancing-chemical-equations_en.html*
    - Thermochemical reactions: *http://cdac.olabs.edu.in/?sub=75&brch=12&sim=92&cnt=150*
    - Worksheet sample (Refer Appendix 9(a) and 9(b))

Challenge Your Thinking

1. Calcium is made to react with zinc carbonate to produce calcium carbonate and zinc. The reaction is illustrated below.



Refer the illustration and answer the following questions.

(i) Calculate the amount of zinc present in zinc carbonate.

(ii) State the law that is demonstrated in the above reaction.

2. A student investigated the effect of temperature on the rate of reaction. During the investigation he mixed two colourless solutions A and B and observed that the solutions turned blue after sometime.
The observations were recorded in the table below.

Temperature (^{0}C)	22	25	34	45	51
Time taken to turn the solution blue (sec)	290	250	200	170	160

Refer the data and answer the following questions.

(i) Plot a graph for these results.

(ii) Use the graph to find out how long it takes to turn the solution blue at 40 ^{0}C.

(iii) How does the rate change as the temperature increased?

(iv) Explain in terms of particles why temperature has this effect on the rate of reaction.

1.2 Curriculum Content (Class X)

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 particle theory and gas laws.

Competencies:

- Demonstrate the conceptual understanding of the behaviour of gases and gas laws to relate it to the everyday life.

Objective(s):

Gas Laws

i. Explore the particle theory and relate it to the behaviour of gases.

ii. Explore Boyle's law, Charles' law, Gay-Lussac's law and Avogadro's law to explain the relationship among different variables such as pressure, temperature, volume and number of particles.
iii. Design an experiment, formulate data, and represent the result graphically to verify Boyle's law, Charles' law, Gay-Lussac's law, and Avogadro's law.
iv. Derive equations for gas laws using mathematical and computational thinking.
v. Solve numerical problems using the gas law equations.
vi. Use the principles of gas laws to design a device that can be used in your locality.
vii. Develop a simulation to demonstrate the behaviour of gas.

1.2.1.1 Gas Laws

- Particle theory (*Scope: Statement of particle theory of matter and behaviour of gases*).
- Boyle's law (*Scope: statement of Boyle's law, derivation of Boyle's equation, experimental verification of Boyle's law, numerical problems, graphical representation, real-life application of the law*).
- Charles' law (*Scope: statement of Charles' law, derivation of Charles' equation, experimental verification of Charles' law, numerical problems, graphical representation, real-life application of the law*).
- Gay-Lussac's law (*Scope: statement of Gay-Lussac's' law, derivation of Gay-Lussac's equation, experimental verification of Gay-Lussac's law, numerical problems, graphical representation, real-life application of the law*).
- Avogadro's law (*Scope: statement of Avogadro's law, derivation of Avogadro's equation, experimental verification of Avogadro's law, numerical problems, graphical representation, real-life application of the law*).
- Gas equation (*Scope: derivation of gas equation and numerical problems*).
- Ideal gas equation (*Scope: derivation of ideal gas equation and numerical problems*).

Learning Experiences:

The teacher may use Predict-Observe-Explain (POE) to deliver the lesson.

- The learner predicts pressure-volume relationship, volume–temperature relationship, and volume- number of moles relationship to study the behaviour of gases.
- The learner in team designs an experiment and carries out the investigation to verify the above relationships. In case of volume-number of moles relationship, the learner may use virtual laboratory on *https://phet.colorado.edu/sims/html/gas-properties/latest/gas-properties_en.html* or *https://javalab.org/en/avogadros_law_en/*
- The learner records the observations and plots graphs based on the data.

- The learner interprets the graphs to infer the relationship between pressure-volume, volume–temperature, and volume-number of moles of a gas.
- Based on the above inference, the learner draws the generalization and names the three gas laws.
- The learner explains pressure-volume relationship, volume–temperature relationship, and volume-number of moles relationship based on the observation and inference made.
- The learner derives the equations for Boyle's law, Charles' law, and Avogadro's law, and solves numerical problems based on these laws
- The learner combines Boyle's law and Charles' law equations to derive an equation and uses the equation to solve the numerical problems.
- The learner combines all the three gas law equations to derive an ideal gas equation and uses the equations to solve the numerical problems.
- The learner explains the real-life application of gas laws.
- The learner designs a device based on the principles of gas laws and advertises the design in social media.
- Based on the design, the learner constructs the prototype of the device.
- The learner designs a simulation that explains the behaviour of gas.

Assessment:

- The teacher may use assessment techniques such as question answer, Directed Activities Related to Text (DARTs), game, crossword puzzle, review, report writing, etc. to assess the learner's conceptual understanding of alcohol. The teacher may use the link (*https://hot-potatoes.en.uptodown.com/windows/download*) to download software to help create assessment tool.
- The teacher may assess the learner's skills in collaboration, presentation, information management, communication, differentiation, analysis, data interpretation, investigation, and creation while designing a device and prototype, designing an experiment, solving numerical problems, and exploring information on gas laws.
- The teacher may assess the learner's scientific values and attitude 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
- Class X chemistry (2016), Kuensel Corporation Ltd.
- National School Curriculum Framework (NSCF-2021)

- Pressure-volume relationship:
  https://upload.wikimedia.org/wikipedia/commons/1/15/Boyles_Law_animate d.gif
- Volume-temperature relationship:
  https://upload.wikimedia.org/wikipedia/commons/e/e4/Charles_and_Gay-Lussac%27s_Law_animated.gif
- Volume-number of moles relationship
  https://i.pinimg.com/originals/8c/fc/0c/8cfc0c7422c69e07ea676ee96cc45b63.gif
  Virtual laboratory link:
  http://amrita.olabs.edu.in/?sub=1&brch=5&sim=226&cnt=597
- Video resource link:
  https://www.khanacademy.org/science/ap-chemistry beta/x2eef969c74e0d802:intermolecular-forces-and-properties/x2eef969c74e0d802:ideal-gas-law/e/ideal-gas-law
- Assessment Tools and Technique Offline Software Link:
  https://hot-potatoes.en.uptodown.com/windows/download

Challenge Your Thinking

1. (a) Sonam conducted an experiment in the laboratory to verity Boyle's law for a certain gas. After performing the experiment, Sonam obtained the following set of data.

Pressure (atm)	0.9	1.2	1.3	1.5	1.8	1.9	2.1
Volume (cm^3)	24.9	18.6	17.1	15.0	12.1	11.5	10.2

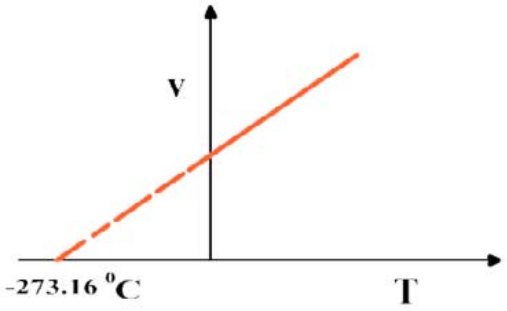
Based on the data, answer the following questions.

(i) Find whether the gas obeys Boyle's law by plotting graph of pressure vs. volume and pressure vs. inverse volume.
(ii) What conclusion can you draw from the experiment?
(iii) Identify different variables in the experiment.
(iv) Explain Boyle's law with its equation.
(v) Is Boyle's law universally true? If not mention one of its limitations.
(vi) Give two real life examples of Boyle's law.

(b) Solve the following numerical based on Boyle's law.

(i) An astronaut releases a compressed gas into the space during the space mission. The initial volume of the gas is 10 L. what would be the final volume?
(ii) A balloon is transported from Phuentsholing to Thimphu. The volume and the pressure of the ballon in Phuentsholing is 2.0 L and the pressure is 1atm and the pressure in Thimphu is 0.90 atm. Assuming the temperature to be constant, find the volume of ballon in Thimphu.

2. A student conducted an experiment on a certain gas to find the relationship between temperature (T) and the volume (V). Using the data obtained, a graph was obtained as shown in the figure below.



Use the figure to answer the following questions.

(i) Which gas law does the plot verify?

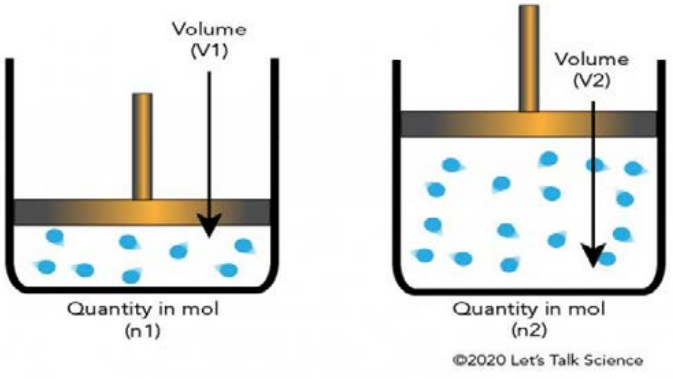
(ii) Define the law

(iii) Identify variables in the plot.

(iv) Does the volume of the gas reduce to half the original volume, if the temperature is reduced from 100 degree Celsius to 50 degree Celsius? Give reason.

3. (a) A balloon filled with helium gas at 22°C and 760 mm Hg. It is then placed outside on a hot summer day when the temperature is 31 ^{0}C. If the pressure remains constant, what will be the volume of balloon?

(b) The figure below demonstrates the behaviour of a certain gas.



Study the figure and answer the following questions.

(i) Which gas law does the figure demonstrate?

(ii) Define the law based on the figure.

(iii) Sonam was driving his car from Thimphu to Phuentshloing. The tyre of his car containing 10 moles of air and occupying a volume of 40L loses half its volume due to a puncture on the way. Considering that the pressure and temperature remain constant, what would be the amount of air in the deflated tyre?

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 alcohols and metallurgy.

Competencies:

- Interpret the chemistry of alcohol to evaluate its impact on health, economy, society, environment, industry and in the field of medicine.
  Objective(s):
  Alcohols
  i. Explain a homologous series of alcohol and functional group to observe a regular pattern in the structure after exploring the information through relevant sources.
  ii. Classify the alcohol based on the number of hydroxyl group.
  iii. Design 2D/3D molecular model of alcohol.
  iv. Use IUPAC rules to name alcohols.
  v. Design an experiment to investigate the properties of alcohol.
  vi. Design a breath analyzer that may be used by traffic police.
  vii. Explain the chemistry behind the breath analyzer.
  viii. Formulate a hand sanitizer based on the properties of alcohol.
  ix. Explain a method in which ethanol is made non-consumable to humans after exploring the information through relevant sources.
  x. Design an experiment to outline the process for preparation of ethanol.
  xi. Carry out a case study related to the impact of alcohol on health, economy, society, environment, industry and in the field of medicine.
  xii. Debate on national policies related to alcohol such as issuance of bar license, sale of alcohol, age limit for drinking, etc.
  xiii. Advocate on health and social impact of alcohol to educate the community.

- Outline the basic steps of metallurgy to understand the significance of metals and their alloys in contributing towards human welfare, civilization, culture, and the environmental impact.
  Objective(s):
  Metallurgy
  i. Explain the terms metallurgy, ores, minerals, charge, gangue, flux, slag, calcination and roasting to evaluate their significance in the process of extraction of metals after exploring the information through relevant sources.
  ii. Explain the steps involved in metallurgy by creating a flowchart using any drawing tools.
  iii. Predict reactivity of metals based on the reactivity series.
  iv. Design an experiment to demonstrate the electro-refining of metals.
  v. Research on the significance of metals in contributing towards human welfare, civilization, culture, and environment.
  vi. Explain nano-alloying as an emerging technology.
  vii. Design a canister for soft drink based on the knowledge of properties of metals/alloys.

1.2.2.1 Alcohols

- Alcohols (*Scope: homologous series and functional group, alcohol as hydroxyl derivatives of alkane, structural representation, classification, nomenclature*).
- Properties of alcohol (*Scope: physical and chemical properties [combustion, oxidation, esterification, and dehydration] of alcohol*).
- Denatured alcohol (*Scope: definition, and identification of alcohol*).
- Preparation and uses of ethanol (*Scope: ethanol from starch by fermentation and ethanol from ethene by hydration*).
- Ethanol and its impacts (*Scope: impact on environment, economy, society, and health*).

Learning Experiences:

Alcohols

The teacher may use flipped - classroom to deliver the lesson. The teacher uploads the reading material on homologous series of alcohol, functional group, types of alcohol and IUPAC rules to name some alcohols using online learning platform one or two days before the lesson.

Outside Class:

- The learner explores the information from the uploaded material before the lesson.
- The learner notes down the homologous series of alcohol, functional group, structural formula, and types of alcohol, and prepares the PowerPoint Presentation

In Class:

- Face to face discussion with peers and seek feedback from teacher on the material prepared.
- The presentation includes 3D model or simulation of structure of alcohol.
- The learner applies IUPAC rules to name some alcohols.

Properties of Alcohol

The teacher may use laboratory investigation to deliver the lesson.

- The learner explores the information on physical and chemical properties of alcohol.
- Based on the information, the learner designs an experiment and carries out the investigation to verify chemical properties.
- The learner in team designs a breath analyser and explains the chemistry used in working of breath analyser.
- Based on the knowledge of alcohol, the learner formulates a hand sanitizer that may be used in school and present the formulation to the class.
- The learner explores how ethanol is made unfit for consumption and shares their finding to the class.

Preparation and Uses of Ethanol

Preparation of Ethanol:

The teacher may use Project Based Learning (PBL) to explore the preparation of ethanol

- The learner in team prepares a plan for the project.
- The learner in team carries out the project as per the plan.
- The learner presents the project report to the class.

Uses of Ethanol:

The teacher may use integrative learning to deliver the lesson.

- The learner explores the information on manufacture and uses of ethanol.
- The learner completes the worksheet provided by the teacher on manufacture of ethanol.
- The learner identifies the raw materials, process and writes the chemical equation for the preparation of ethanol.
  The learner identifies and names five products where ethanol is used.

Ethanol and Its Impacts

Teacher may use case study to deliver the lesson.

- The learner reads the article titled **"The Myth behind Alcohol Happiness"** by Dr. Chencho Dorji using the link *http://www.bhutanstudies.org.bt/publicationFiles/ConferenceProceedings/RethinkingDevelopment/8.Re-thinkingdev.pdf.*
- After reading the article, the learner analyses impact of alcohol on the social, economic, and health aspect of a consumer.
- Based on the analysis, the learner answers following questions.
- As per the article, alcohol is one of the leading causes of death in Bhutan. Argue for or against this statement.
- Discuss social and economic impacts of alcohol.
- The government has lifted the ban on the issuance of bar license in the country. Share your view on this policy.
- The learner creates a video using multimedia tool to create awareness on health and social impacts of alcohol and discourage people from misuse of alcohol.
- The learner shares the video to the class.
- The learner explores the information on the environmental impact of alcohol and makes the presentation to the class.
- The learner conducts a case study related to alcohol on health, economy, society, environment, industry and in the field of medicine.
- The learner selects the learning sites, does sampling and identifies instrument for data collection.
- The learner conducts the study and collects the data.
- The learner analyses the data and produces the report on mitigation and impacts assessed.

- The learner may debate on national policies issues related to alcohol.

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 attitude 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
- Class X chemistry (2016), Kuensel Corporation Ltd.
- National School Curriculum Framework (NSCF-2021)
- Article link: *http://www.bhutanstudies.org.bt/publicationFiles/ConferenceProceedings/Re t hinkingDevelopment/8.Re-thinkingdev.pdf.*

Challenge Your Thinking

1. A student designs an experiment to investigate the property of ethyl alcohol using ethyl alcohol, acetic acid and conc. H_2SO_4.
   (i) Write the procedure to conduct the investigation
   (ii) What are the reactants and the products in the reaction?
   (iii) Write the chemical equation for the reaction.
   (iv) What is your observation in the experiment?

2. We often hear about drivers who are charged with drunken driving after an accident, and usually a news report on the accident talks about driver's blood alcohol level. For public safety, police officers use Breathalyser to test the level of alcohol
   (i) What is the principle used in Breathalyser?
   (ii) Drinking too much of alcohol leads to change in mood, behaviour, and loss of coordination while moving. Which part of the body is affected by alcohol here?
   (iii) How is ethyl alcohol manufactured in industries? Write the equation.
   (iv) What is denatured alcohol?

1.2.2.2 Metallurgy

- Metallurgy (*Scope: definition of metallurgy, some terminologies such as ores, minerals, charge, gangue, flux, slag, calcination, roasting, basic steps of metallurgy such as dressing of ore, concentration of ores, extraction of metals from the concentrated ores, purification of metals including electro-refining, introduction to alloys, nano-alloys, and their uses, significance and impacts of metals in contributing towards human welfare, civilization, culture and the environment*).

Learning Experiences:

Metallurgy

The teacher may use blended learning to deliver the lesson.

- The learner explores different terms and steps involved in the process of extraction of metals and notes down the terms.
- Using the terms as reference, the learner uses the video links *https://www.youtube.com/watch?v=7jMbIUXB-aQ* and *https://www.youtube.com/watch?v=2xWO11680mM* that explain the process involved in extraction of metals.
- Based on the information from the video, the learner creates a flow chart to summarize the basic steps involved in the extraction of metals.
- The learner presents the flowchart to the class.
- The learner in team designs and carries out the experiment to demonstrate the electro-refining of metals.
- The learner in team engages in gallery walk to observe design of other teams and exchange ideas.
- The learner relates the significance of metals to human welfare, civilization, culture, and environment and writes a report.
- The learner debates on the advantages and disadvantages of metal extraction to evaluate the benefits and implications on use of metals.
- The learner explores information related to nano-alloy as an emerging field of studies using relevant sources.
- The learner designs a metal canister for beverage industry based on the knowledge of properties of metals. Provide a scientific justification for choosing a particular metal for 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 terms and steps involved in metal extraction and the alloy.
- The teacher may assess the learner's skills in collaboration, presentation, information management, communication, differentiation, analysis, investigation, and creation while exploring information on terms and steps involved in metal extraction.
- The teacher may assess the learner's scientific values and attitude such as curiosity, intellectual honesty, perseverance, etc.

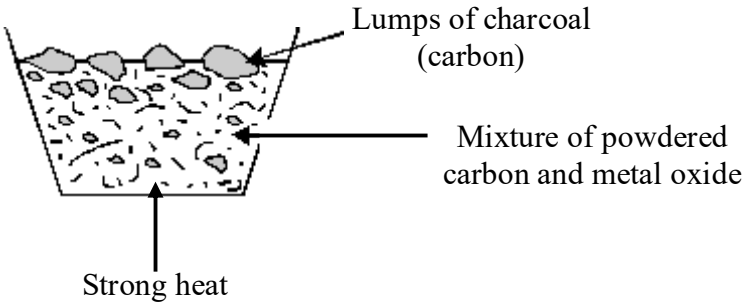
- The teacher may design assessment tools such as rubric, checklist or rating scale to assess the learner and accordingly provide necessary intervention.
- For recording and reporting, refer National School Curriculum Framework (NSCF-2021)

Resources:

- REC Repository
- Class X chemistry (2016), Kuensel Corporation Ltd.
- National School Curriculum Framework (NSCF-2021)
- Video links:
  https://www.youtube.com/watch?v=7jMbIUXB-aQ
  https://www.youtube.com/watch?v=2xWO11680mM
- Related links:
  https://www.youtube.com/watch?v=W4c7dOPG9OI
  https://www.youtube.com/watch?v=8oTdCGj334U
  https://www.youtube.com/watch?v=IuyYDyWvpPE

Challenge Your Thinking

1. A student was trying to extract metal from its oxide ore. The student heated the oxide as shown in the figure below.



With reference to the extraction of metal, answer the following questions.

(i) What happens to the oxide ore when heated with powdered carbon.

(ii) What name is given to this chemical reaction?

(iii) Complete the word reaction between metal oxide and carbon

Metal oxide + C ⟶ ……. + …….

(iv) Bauxite is the ore of aluminium. What is an ore?

2. Mention two reasons for choosing aluminium over other metals to make cans for beverage drinks.
3. Write the main processes involved in metallurgy.

1.2.3 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 (halogens), transition elements, chemical reactions, conservation of mass, mole concept, stoichiometry and energy transfer in chemical reactions.

Competencies:

- Outline the properties of halogens and transition elements to relate their importance in industries, medicine, and other areas of life.

  Objective(s):

  Halogens

  i. Describe the variation in periodic properties of halogens using periodic table.
  ii. Explain the physical properties, chemical properties and uses of halogens using relevant resources.
  iii. Design an experiment to investigate the displacement reaction of halide salts.
  iv. Apply the knowledge of halogens to formulate toothpaste.
  v. Perform qualitative/quantitative analysis for iodine in different samples of salts.
  vi. Research the dietary requirement of iodine for various age group.

  Transition Elements

  vii. Explain the electronic configuration of transition elements in s, p, d, f notation after exploring the information through relevant sources.
  viii. Locate the position of transition elements in the periodic table to relate to their characteristic properties.
  ix. Explain the characteristics and uses of transition metals after exploring the information through relevant sources.
  x. Explain the reason for characteristic properties exhibited by transition elements.
  xi. Perform flame test for transition elements (Fe, Cu, Ni, Mn, Cr and Zn) and relate it to real life application (Miner, Geologist, and Forensic science).
  xii. Perform alkali test with compounds of Fe, Cu and Zn to examine their properties.
  xiii. Explore the application, impact, and influence of transition elements towards development of human culture and civilization.
  xiv. Apply the knowledge of properties of transition elements to formulate a catalyst that may be used in industries in Bhutan.

- Exhibit the knowledge of mole concept and stoichiometry to quantify the substances in chemical reaction for industries and to carry out quantitative analysis in laboratories.

  Objective(s):

  Mole Concept and Stoichiometry

  i. Explain relative atomic mass, gram atomic mass, relative molecular mass, Avogadro's number, and number of moles of elements and compounds using relevant mathematical expressions.

ii. Calculate number of moles and number of particles in chemical substances using mathematical data.
iii. Apply the knowledge of stoichiometry to formulate a pharmaceutical product which contains the right proportion of chemical composition.
iv. Use mathematical data to calculate percentage composition, empirical formula, and molecular formula.
v. Use balanced chemical equations to calculate mass, volume, and number of particles of chemical substances.
vi. Design an experiment to calculate the number of particles in a sample of chemical substance using the knowledge of stoichiometry.
vii. Apply the knowledge of mole concept to calculate the exact amount of nitrogen gas required in the car air bags to protect the driver and the passenger during head on collision.

- Relate the fundamental concepts and principles of thermodynamics to understand inter-conversion of energy and physical processes taking place in the universe.

  Objective(s):

  Energy Transfer in Chemical Reactions

  i. Explain the concept and significance of internal energy, enthalpy, and entropy to relate to the law of conservation of energy.
  ii. Explain the change in enthalpy graphically to determine the types of thermochemical reactions.
  iii. Explain the sign convention with reference to change in enthalpy, internal energy, and entropy.
  iv. Explain different types of heat of reaction with examples.
  v. Discuss the applications of energy change in day-to-day life.

1.2.3.1 Group 17: Halogen Group

- Group 17 – Halogens (F, Cl, Br, I, At) and Basic information (*Scope: Occurrence, electronic configuration and stability, safety, and storage*).
- Periodic properties (*Scope: nuclear and effective nuclear charge, atomic size, electronegativity, ionization energy, electron affinity*).
- Physical Properties (*Scope: physical state, colour and solubility, density, melting and boiling points, oxidation state*).
- Chemical Properties (*Scope: combustibility, as oxidizing and reducing agents, as bleaching agent, displacement reaction, reaction with alkali metals, water, and hydrogen*).
- Uses of halogens (*Scope: uses of fluorine, chlorine, bromine, iodine, and astatine*).

Learning Experiences:

Group 17 - Halogens

The teacher may use blended and game-based learning to deliver the lesson. The teacher uploads the reading material on occurrence and source, safety and storage, electronic configuration, and effective nuclear charge of halogens on Google Classroom or any other online learning platform one or two days before the lesson.

- The learner explores the information from the uploaded material before the lesson.

- The learner notes down the occurrence and source, safety and storage, electronic configuration and effective nuclear charge of halogen and participates in game-based activities such as crossword puzzle, word jumble, hangman, etc.
  https://www.hangmanwords.com/create
  https://crosswordlabs.com/edit/halogen-75

Properties and Uses of Halogen

The teacher may use 5E Model to deliver the lesson.

Question:

What are the characteristic properties of halogen?

Engage

- The learner in team discusses the characteristic properties of halogen.

Explore

- The learner in team explores the variation in the periodic properties of halogen such as atomic size, electronegativity and electron affinity using interactive periodic table.
- The learner in team discusses the properties of halogens such as physical state, color and solubility, density, melting and boiling point, oxidation state, combustibility, reducing and oxidizing agent, bleaching action, displacement reaction, reaction with alkali metals, reaction with hydrogen, and uses of halogens.

Explain

- The learner explains the chemistry of halogens and their applications. The learner makes PowerPoint Presentation and presents to the class.

Elaborate

- The learner explains the trends in the periodic properties of halogens.
- The learner examines the physical properties of halogens.
- The learner carries out experiment to verify that a more reactive halogen displaces less reactive halogen from its compound.
- The learner formulates a toothpaste based on the knowledge of halogens.
- The learner may assign a brand name for the formulation and advertise in social media.

Evaluate

- The learner takes part in quiz or creates a concept map.

Assessment:

- The teacher may use assessment techniques such as question answer technique, DARTs, game, crossword puzzle, review, report writing, etc. to assess the learner's conceptual understanding on periodic properties, physical and chemical properties, and uses of halogens.
- The teacher may assess the learner's skills in collaboration, presentation, information management, communication, differentiation, analysis, investigation, and creation while formulating the toothpaste, designing an experiment, and

exploring information on periodic properties, physical and chemical properties, and uses of halogens.

- The teacher may assess the learner's scientific values and attitude 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
- Class X chemistry (2016), Kuensel Corporation Ltd.
- National School Curriculum Framework (NSCF 2021)
  https://www.hangmanwords.com/create
- *https://crosswordlabs.com/edit/halogen-75*

Challenge Your Thinking

1. The table below shows the information on halogens.

Atomic number	Element	Symbol	Electronic configuration	Electronegative value
9	Fluorine	F		4
17		Cl		3
35		Br	2,8,18,7	2.8
53		I	2,8,18,8,7	2.5

Refer the table and answer the following questions

(i) Complete the table

(ii) How many electrons are present in the valence shell of halogens?

(iii) What type of bond is formed between metals and halogens?

(iv) Why does electronegativity value decrease down the group?

2. Answer the following questions;

i. Arrange the following halide in increasing order of their reducing property.
F, Br, Cl and I.

xii. Why does the reactivity of halogen decrease as we move down the group.

xiii. what happens when chlorine solution is added to a solution of sodium bromide?

1.2.3.2 Transition Elements

- Electronic configuration and position in periodic table (*Scope: Electronic configuration in s, p, d, f notation, position in the periodic table*).
- Characteristics of transition elements (*Scope: metallic character, melting and boiling points, colour, ionization potential, atomic volume and densities, low reactivity, magnetic properties, variable oxidation state, complex ion formation catalytic properties*).

- Reaction involving transition elements (*Scope: Reaction of Fe, Cu and Zn with alkali*).
- Application (*Scope: Uses, impact and influence of transition elements towards development of human culture and civilization*).

Learning Experiences:

The teacher may use Process Oriented Guided Inquiry Learning (POGIL) to deliver the lesson. The teacher provides the worksheets on fundamental of transition elements, s, p, d, f electronic configuration, position in periodic table, characteristics, reactions of transition elements and their uses (*Refer Appendix 10 (b)for sample*). The teacher may use four different worksheets in different sessions.

The learner follows the instruction provided in the worksheet to carry out the following tasks.

- The learner in team discusses fundamentals of transition elements, position in the periodic table, and electronic configuration using s, p, d, f notation.
- The learner in team discusses the characteristics of transition elements in relation to electronic configuration and also the chemistry of transition elements.
- The learner in team discusses uses of transition elements in relation to their characteristics.
- The learner performs flame test for transition elements (Fe, Cu, Ni, Mn, Cr and Zn) and relates it to real life application (Miner, Geologist, and Forensic science) through laboratory experimentation or virtually by following the link (*https://www.newpathonline.com/api_player/enus_54_6603/TQUfJ0/index.html).*
- The learner performs alkali test with compounds of Fe, Cu and Zn to examine their properties.
- The learner in team explores and discusses the application, impact, and influence of transition elements towards development of human culture and civilization from relevant sources.
- The learner formulates a catalyst for an industry based on the knowledge of transition elements and present it to the class.
- The learner submits the worksheets to the teacher for feedback and evaluation.

Assessment:

- The teacher may use assessment technique such as question answer technique, DARTs, game, crossword puzzle, review, report writing, etc. to assess the learner's conceptual understanding of fundamental of transition elements, s, p, d, f electronic configuration, position in the periodic table, characteristics, and uses of transition elements.
- The teacher may assess the learner's skills in collaboration, presentation, information management, communication, differentiation, analysis, investigation,

and creation while formulating the catalyst/alloy, designing an experiment, and exploring information on fundamental of transition elements, s, p, d, f electronic configuration, location, characteristics, and uses of transition elements.

- The teacher may assess the learner's scientific values and attitude 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)

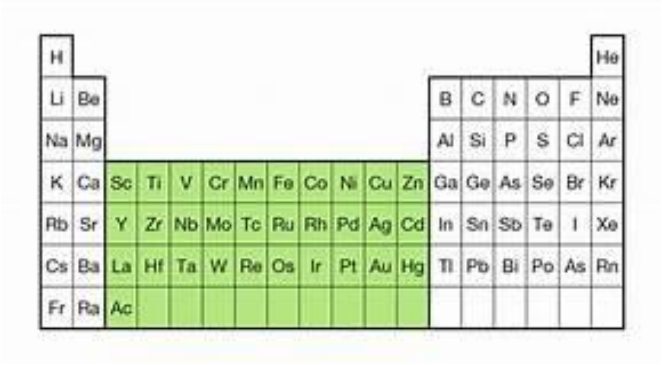
Resources:

- REC Repository
- Class X chemistry (2016), Kuensel Corporation Ltd.
- National School Curriculum Framework (NSCF 2021)
- Video links:
  https://youtu.be/jLErqSzJoZo
  https://youtu.be/zQgyrBnsprU
  https://cdn.kastatic.org/ka-youtube-converted/kCM2mSb4qIU.mp4/kCM2mSb4qIU.mp4#t=0
  https://youtu.be/Nq4Gy_518F0
  https://www.youtube.com/watch?v=diCGRJskeDA

- Virtual laboratory link:
  https://www.newpathonline.com/api_player/enus_54_6603/TQUfJ0/index.html

Challenge Your Thinking

2. The figure below shows the periodic table highlighting transition elements.



With reference to transition elements, answer the questions that follow.

(i) Why'd block elements are called transition elements?

(ii) Write two properties of transition elements

(iii) Hydrated copper sulphate is transition metal compound which is blue. Why do transition elements form coloured compounds?

(iv) What are the metallic characters of transition elements?

(v) What are transition elements often used for in industry?

2. Explain the following;
    i. Transitions elements usually show variable oxidation state.
    ii. Transition metals are used as catalyst
    iii. Transition elements show coloured complexes.

1.2.3.3 Group 17: The Mole Concept and Stoichiometry

- Terms related to mole concept (*Scope: definition of relative atomic mass, gram atomic mass, relative molecular mass, gram molecular mass, Avogadro's number, mole concept and related numerical problems*).
- Percentage composition, empirical formula, and molecular formula (*Scope: definition of percentage composition, empirical formula molecular formula and related numerical problems, differences between empirical formula and molecular formula*).
- Calculation based on chemical reactions (*Scope: calculations based on mass-mass relationship, mass-volume relationship, volume-volume relationship, and mass- number of particles relationship*).
- Application (*Scope: production industries, quantitative analysis in the laboratory, amount of reactants and products*).

Learning Experiences:

Mole concept

The teacher may use Atkin and Karplus learning cycle to deliver the lesson. The teacher provides the worksheet on the concept of mole (*Refer Appendix 10(a) for sample*).

Explore

- The learner explores counting and measurement units such as dozen, pair, pon, score, gram, litre, ream, etc. to relate them to the concept of mole.

Concept development

- The learner follows the instruction and completes the worksheet provided.
- The learner relates the concept of mole to atomic mass, molecular mass, Avogadro's number, and molar volume by completing the task in the worksheet.
- The learner submits the worksheet to the teacher for feedback and comment.

Concept application

- The learner calculates the number of particles in common salt, if the dietician recommends daily intake of 6g salt in the normal diet.

Percentage Composition, Empirical Formula and Molecular Formula

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

Explore

The learner analyses the nutrition label of varieties of consumer product to evaluate and compare the data in the food product and converts the values to moles or the learner may use the following analogy to perform quantitative analysis of Oral Rehydration Solution (ORS) composition.

- The learner prepares ORS by dissolving 10g of sugar and 5g of common salt in 100g of water.
- The leaner calculates the percentage composition of sugar, salt, and water in ORS.
- Using the above analogy, the learner identifies different components in H_2O, CO_2, HCl and calculates the percentage composition of each component in the compounds.
- The learner determines the percentage composition of elements in the different compounds provided by the teacher and calculates their empirical formula and molecular formula.
- The learner submits the work to the teacher for feedback and comment.

Concept development

- The learner relates the percentage composition, empirical formula, and molecular formula of a compound.
- The learner differentiates and identifies empirical formula and molecular formula of a compound.
- The learner explains the relationship and the difference to the class.

Concept application

- The learner applies the knowledge of percentage composition to formulate a pharmaceutical product.

Calculation Based on Chemical Reactions

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

Explore

- The learner explores the relationship between mass-mass, mass-volume, volume-volume, and mass-number of particles in the given equation.

$$H_2 + Cl_2 \longrightarrow 2HCl$$

Concept development

- The learner calculates the volume of HCl produced from 6 L of hydrogen at STP.
- The learner calculates the mass of HCl produced from 6 g of hydrogen at STP.
- The learner calculates the mass of HCl produced from 6 L of hydrogen at STP.
- The learner calculates the number of HCl particles produced from 6 g of hydrogen at STP.
- The learner may practice similar numerical problems.

Concept application

- The learner calculates the amount of pollutant produced when the car consumes 5 L of petrol while traveling from Paro to Thimphu.
- The learner applies the knowledge of mole concept to calculate the exact amount of nitrogen gas required in the car air bags to protect the driver and the passenger during head on collision.

Assessment:

- The teacher may use assessment techniques such as question answer technique, DARTs, game, crossword puzzle, review, report writing, etc. to assess the learner's conceptual understanding mole concept, percentage composition, empirical formula and molecular formula, and calculation based on chemical equation.
- The teacher may assess the learner's skills in collaboration, presentation, information management, communication, differentiation, analysis, investigation, and creation while formulating pharmaceutical product, computing skill, and exploring information on mole concept, percentage composition, empirical formula and molecular formula, and calculation based on chemical equation.
- The teacher may assess the learner's scientific values and attitude 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
- Class X chemistry (2016), Kuensel Corporation Ltd.
- National School Curriculum Framework (NSCF 2021)

Challenge Your Thinking

1. a. A student designed an experiment to find the number of particles in sodium chloride to investigate the number of particles in a given sample of table salt. To calculate the number of particles, he uses the Avogadro's number.
   Answer the questions that follow.
   (i) Mention briefly the procedure of your experimental design.
   (ii) If the students finds the weight of the sodium chloride to be 28.5g, calculate the number of particles. [Na=23, Cl= 35.5]
   (iii) What is Avogadro's number?

   b. Stoichiometry is present in daily life like to help us determine the amount of substance in a chemical reaction. The following questions are with reference to stoichiometry.

   c. Penicillin, the first of a now large number of antibiotics (antibacterial agents), was discovered accidentally by the Scottish bacteriologist Alexander Fleming in 1928, but he was never able to isolate it as a pure compound. This and similar antibiotics have saved millions of lives that might have been lost to infections. Penicillin F has the formula $C_{14}H_{20}N_2SO_4$. Compute the mass percent of each element. [C= 12, H=1, N=14 S=32 O=16]

d. Caffeine, a stimulant found in coffee, tea, and chocolate, contains 49.48% carbon, 5.15% hydrogen, 28.87% nitrogen, and 16.49% oxygen by mass and has a molar mass of 194.2 g/mol. Determine the molecular formula of caffeine. [C= 12, H=1, N=14, S= 32, O=16]

2. a. Lithium hydroxide is used in space vehicles to remove exhaled carbon dioxide from the living environment by forming solid lithium carbonate and liquid water.

$2LiOH + CO_2 \longrightarrow Li_2CO_3 + 3H_2O$

What mass of gaseous carbon dioxide can be absorbed by 1.00 kg of lithium hydroxide? [Li=6, H= 1, C= 12]

b. Karma has 5.6 X 10^{24} atoms of helium gas to fill balloons at a ball game. If each balloon holds 1.5 litres of helium, how many balloons can he fill? Assume STP.

1.2.3.4 Energy Transfer in Chemical Reactions (Chemical Energetics)

- Internal Energy, Enthalpy and Entropy (*Scope: description of Law of conservation of energy, definition of internal energy (E), change in internal energy (ΔE), and sign convention. Definition of enthalpy (H), graphical representation of change of enthalpy, change in enthalpy (ΔH), and sign convention. Definition of entropy (S), change in entropy (ΔS), sign convention and its significance*).
- Heat of Reaction (*Scope: definition of heat of reaction, types of heat of reactions (combustion, neutralization, formation, and stability) with examples, applications of energy change*).

Learning Experiences

The teacher may use reflective learning to deliver the lesson.

- The learner uses PhET simulation *https://phet.colorado.edu/sims/html/energy-skatepark/latest/energy-skate-park_en.html* to verify the law of conservation of energy and states the law of conservation of energy.
- The learner designs an experiment and investigates the change in enthalpy *(Refer Appendix 10(c) for sample)* and relate it to internal energy and entropy change. The learner gets familiar with sign convention.
- After the investigation, the learner relates internal energy, enthalpy, and entropy to the law of conservation of energy.
- The learner in team presents the findings to the class using PowerPoint Presentation.
- The learner designs experiments and investigates heat of neutralization and heat of formation and records the observation.
- Based on the observation, the learner differentiates the two types of reaction and present to the class for feedback and comment.
- The learner reflects on the applications of energy change in daily life and shares it to the class.

- The learner designs a device using the concept of energy change and advertises through social media.
- The learner explains the science behind the working of the device.

Assessment:

- The teacher may use assessment techniques such as question answer technique, DARTs, game, crossword puzzle, review, report writing, etc. to assess the learner's conceptual understanding of law of conservation of energy, enthalpy, entropy, and internal energy.
- The teacher may assess the learner's skills in collaboration, presentation, information management, communication, differentiation, analysis, investigation, and creation while designing experiments, designing a device, and exploring information on law of conservation of energy, enthalpy, entropy, and internal energy.
- The teacher may assess the learner's scientific values and attitude 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
- Class X chemistry (2016), Kuensel Corporation Ltd.
- National School Curriculum Framework (NSCF-2021)
- PhET simulation:
  https://phet.colorado.edu/sims/html/energy-skate-park/latest/energy-skate-park_en.html

Challenge Your Thinking

1. (a) The following questions refer to enthalpy and entropy. Answer the questions that follow.
   (i) H_2 and O_2 react to produce water according to the following equation. $2H_2(g) + O_2(g) \longrightarrow 2H2O$ (l). Will the entropy increase or decrease in the reaction. Give reasons.

   (ii) What is entropy?

   (b) The combustion of one mole of methane, CH_4, releases 890KJ/mole of heat according to the following equation.
   $$CH_4 + 2O_2 \longrightarrow CO_2 + 2H_2O; \quad \Delta H = -890.4 \text{ kJ}$$
   (i) The enthalpy,ΔH, for the reaction is -890.4kJ. What does negative ΔH indicate?

(ii) Calculate the energy given off when 2 moles of CH_4 is burned.

2. A laboratory assistant demonstrates the oxidation reaction by burning a magnesium ribbon in oxygen and obtains the following data.

Reactants			*Products*
Magnesium +	*Oxygen*	⟶	*Magnesium Oxide*
48.6g	*?*		*80.6g*

(i) Assuming that magnesium is completely burned, predict the amount of oxygen used to produce 80.6g of magnesium oxide.

(ii) What scientific law does this experiment support? Explain.

(iii) Define the term internal energy.

2. APPENDICES

2.1 Weighting and Time Allocation

2.1.1 Class IX

Theme	Topic	Maximum Time Required (minutes)	Weighting (%)
Classifying Materials	Chemical Bond	576	16 %
Materials and Change	Organic Chemistry	828	23 %
	Activity Series of Metals	360	10 %
	Green Chemistry	648	17 %
Patterns in Chemistry	Periodic Table	576	16 %
	Chemical Reactions and Energy Transfer	612	18%
Total		**3600**	**100**

2.1.2 Class X

Theme	Topic	Maximum Time Required (minutes)	Weighting (%)
Classifying Materials	Gas Laws	540	16 %
Materials and Change	Alcohols	612	16 %
	Metallurgy	360	10 %
Patterns in Chemistry	Periodic Table (Halogens)	468	13 %
	Transition Elements	540	15 %
	Chemical Reactions, Conservation of mass, Mole Concept and Stoichiometry	720	20%
	Energy Transfer in Chemical Reactions	360	10 %
Total		**3600**	**100 %**

2.2 Appendix 9(a)

Worksheet: Word Equations and Chemical Equations

Name _____

Direction: *Substitute symbols and formulas for words equations with chemical equation.*

i. Hydrogen + water → water

ii. Sodium chloride + lead (II) nitrate → lead (II) chloride + sodium nitrate

iii. Iron + chlorine → iron (III) chloride

iv. When chlorine gas reacts with methane, carbon tetrachloride and hydrogen chloride are produced.

v. When sodium oxide is added to water, sodium hydroxide is produced.

vi. In a blast furnace, iron (III) oxide and carbon monoxide gas produce carbon dioxide gas and iron.

vii. Iodine crystals react with chlorine gas to produce iodine dichloride.

2.3 Appendix 9(b)

Worksheet on Reaction of Alkali Metals with Air and Water

Direction: *Read the information and complete the questions that follows;*

Reaction with Air

The alkali metals tend to form ionic solids in which the alkali metal has an oxidation number of +1. Therefore, neutral compounds with oxygen can be readily classified according to the nature of the oxygen species involved. Ionic oxygen species include the oxide, O^{2-}, peroxide, O_2^{2-}, superoxide, O_2^-, and ozonide O_3^-. Compounds that can be prepared that contain an alkali metal, M, and oxygen are therefore the monoxide, M_2O, peroxide, M_2O_2, superoxide, MO_2, and ozonide, MO_3. Rubidium and caesium and, possibly, potassium also form the sesquioxide, M_4O_6, which contains two peroxide anions and one superoxide anion per formula unit. Lithium forms only the monoxide and the peroxide.

Activity 1: Complete and balance the following equations;

i) $Li + O_2 \rightarrow$ …….

ii) $Na + O_2 \rightarrow$ …….

iii) $K + O_2 \rightarrow$ ……

Reaction with Water

Metals react with water and produce a metal oxide and hydrogen gas. ... It reacts with hot water to form magnesium hydroxide and hydrogen. It also starts floating due to the bubbles of hydrogen gas sticking to its surface. Metals like aluminium, iron and zinc do not react either with cold or hot water.

Activity 2: Complete and balance the following equations;

i) $Li + H_2O \rightarrow$ …….

ii) $Na + H_2O \rightarrow$ ……

iii) $K + H_2O \rightarrow$ ……

2.4 Appendix 9(c)

Directed Activity Related to Text (DART) Sample

Ionic Bond: Formation of sodium chloride

Check your understanding!

Instruction: Fill in the blanks with appropriate word(s).

It is the reaction between a ……. atom and a chlorine atom. Sodium atom is a metal atom because it has …… electron in its valence/outermost shell, while chlorine atom is a ……. because it has seven electrons in its valence/outermost shell. Since both the atoms have …… shell, they are unstable atoms.

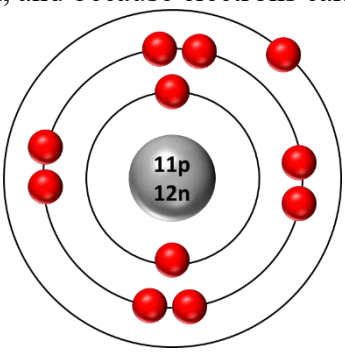
Sodium being a metal atom donates its valence electron (electron belonging to outer most shell), which is then received by the …… atom to complete its valence shell. In this way both atoms become ……

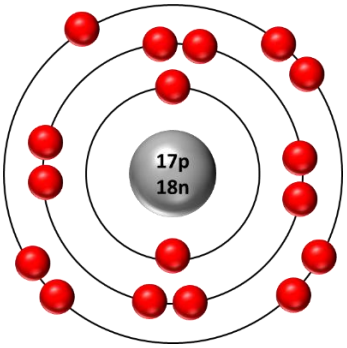
But in this process of achieving stability, the ……. atom loses a negative charge and that negative charge is added to the chlorine atom.

What happens to the overall charge of the atoms?

Let us calculate it!

In a sodium atom there are …….. protons, an d because protons carry positive charge, the atom has a total of …… positive charges. The atom has ……. electron, and because electrons carry negative charge, the atom has 11 …….. charges.





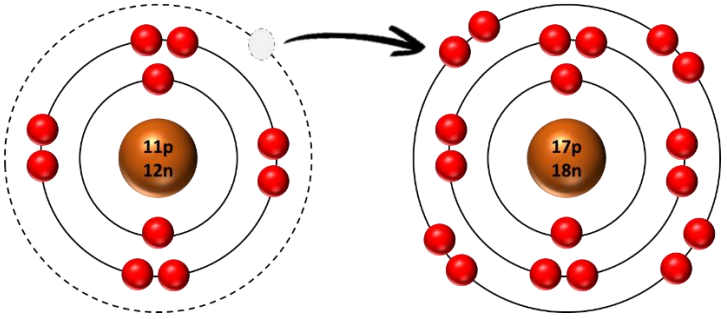
Applying mathematics, +11 – 11 = ……

In a chlorine atom there are 17 protons, so the atom has …… positive charges. The atom has …… electron, so the atom has ……..negative charges.

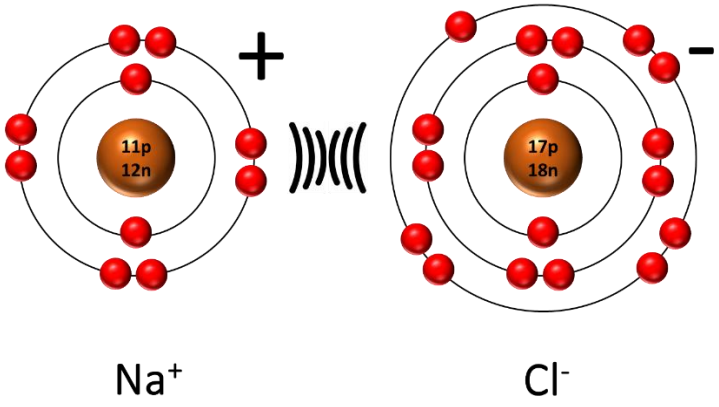
Applying mathematics, +17 – 17 = ……

Since, the overall charge of the atoms is ……., they are considered neutral atoms.

As the …….. atom loses an electron, one ……. charge in the atom decreases. On the other hand, one …… charge is added to the chlorine atom thereby leading to an increase in one negative charge in the atom.



Therefore, the charge on sodium atom would be, + ……. – 11 = …… and the charge on chlorine atom would be, + 17 – …… = -1.

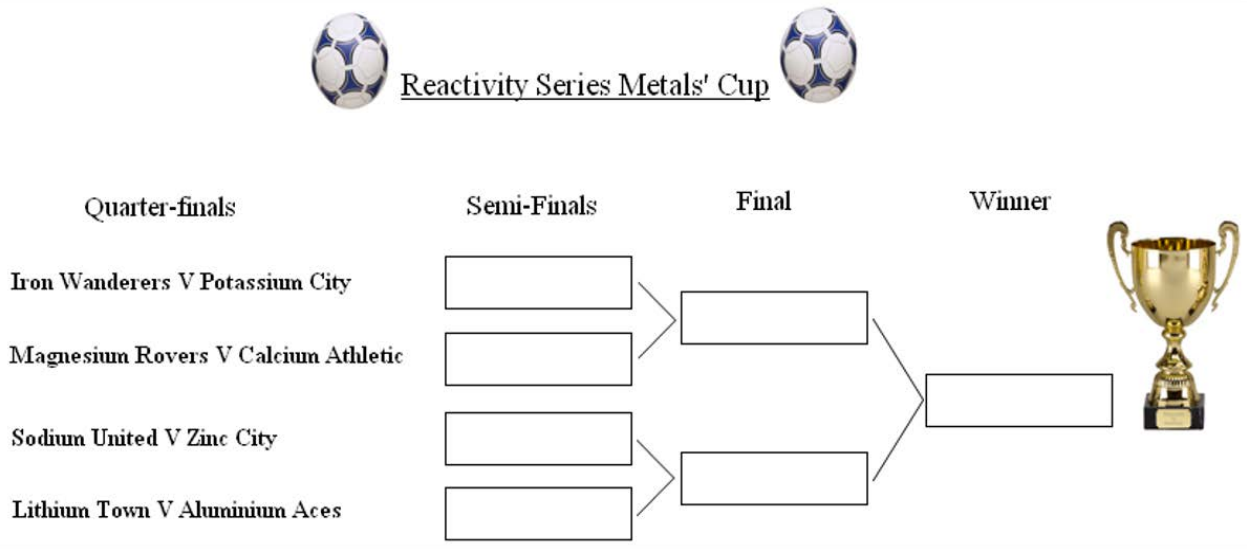


Now that the two atoms are oppositely charged, a …… of attraction develops between them. This force of attraction is called ……..

2.5 Appendix 9(d)

Game based Assessment for Activity Series of Metals.

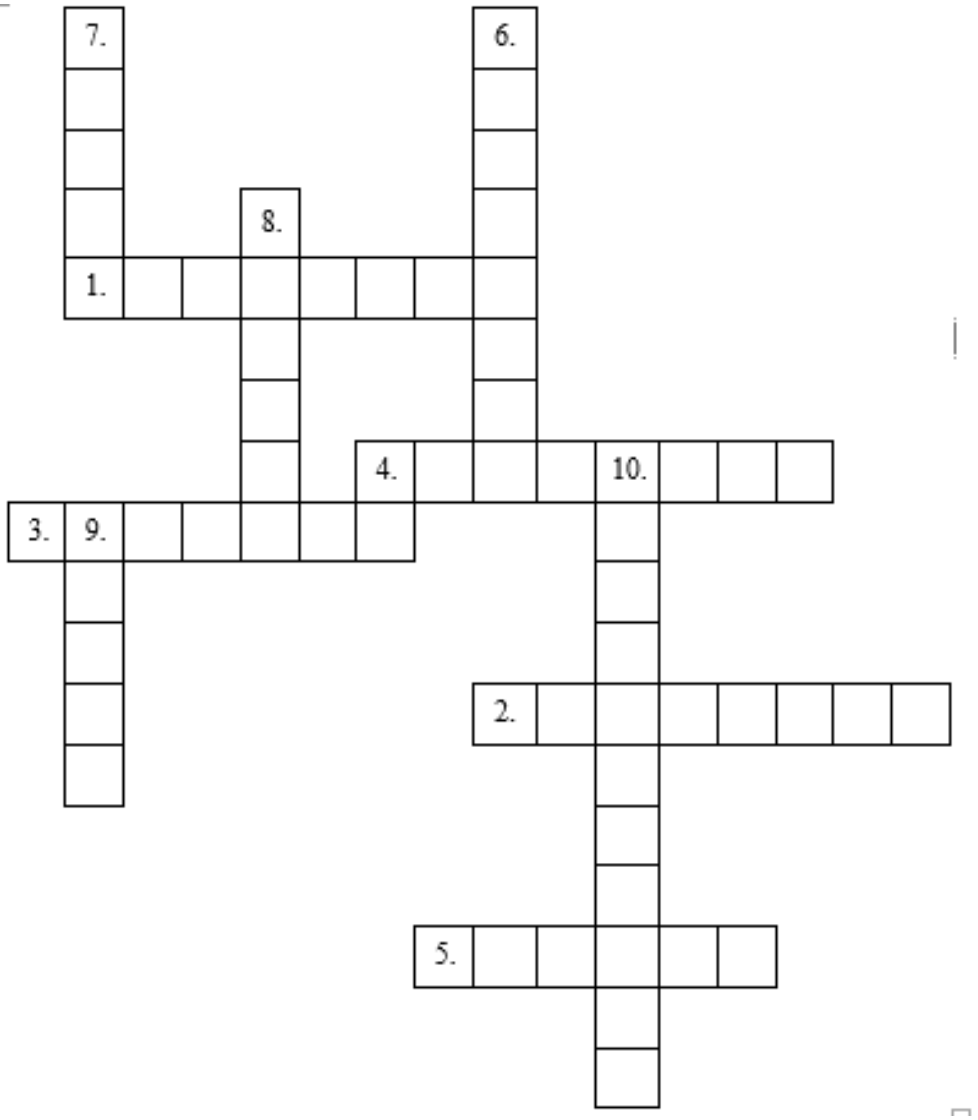
Instruction: Use the knowledge of reactivity series of metals and complete the flow chart.



2.6 Appendix 9(e)

Crossword Puzzle Sample

Read the given clues carefully and write the appropriate word in the boxes to solve the puzzle.



Across

1. A type of bond where two atoms share electrons.
2. The charge of a cation
3. The part of an atom that participate in a chemical bond
4. The sub-atomic particle that revolves around the nucleus of an atom
5. In covalent bond electrons are _____

Down

6. The charge of an anion.
7. A type of bond formed by complete transfer of electron(s)
8. Positively charged ion
9. Negatively charged ion
10. In ionic bond electrons are _____

2.7 Appendix 9(f)

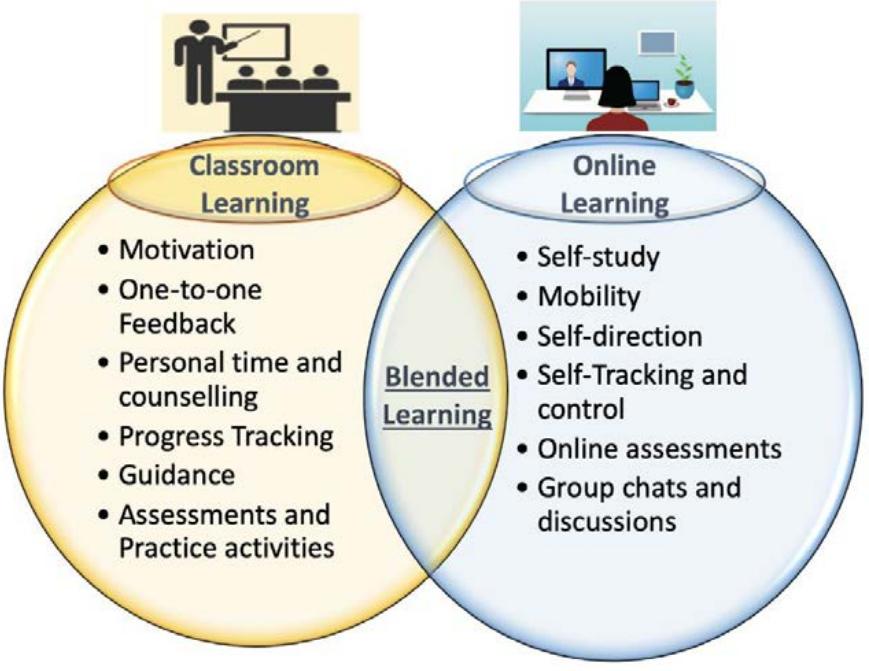
Checklist Sample

Experimental verification of saturated and unsaturated hydrocarbons.

Name	Topic: Saturated and unsaturated hydrocarbon									Teacher's comment
	SK			WS			SV			
	Differentiates between saturated and unsaturated	Draws a graphical representation of saturated and	Gives general formula of saturated and unsaturated	Follows the correct experimental procedures	Handles equipment, apparatus, chemicals safely	Demonstrate ability to set-up experiments	Evaluate the effect of chemicals on environment	Shows curiosity to learn	Demonstrates concern for oneself and others	
Thinley										
Roshan										
Dechen										

2.8 Appendix 9(g)

Blended Learning



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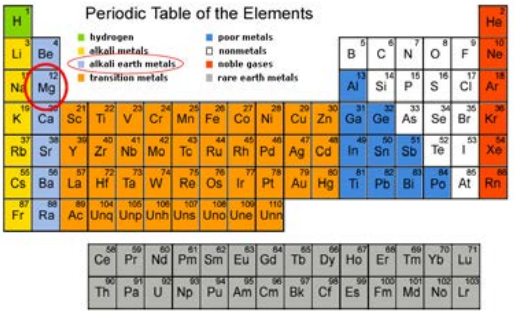
2.9 Appendix 9(h)

Process Oriented Guided Inquiry for Learning (POGIL) Sample for Periodic Trends

(Adapted from Rush Henrietta CSD)

Why:

The Periodic Table is one of the greatest inventions in the history of man. It allows scientists to predict physical and chemical properties of the elements. Dimitri Mendeleev (a Russian scientist) and Robert Mosley (a British chemist) put together this table in the late 1800's based on properties of the elements known at the time. The trends in these properties as you go across periods and down groups is the subject of this Chem POGIL



Success Criteria:

• Understand the meaning of atomic radius, reactivity, electronegativity, ionization energy
• Recognize trends in atomic radius, reactivity, ionization energy and electronegativity as you go across periods and down groups.

Answer the following questions using the resources above.

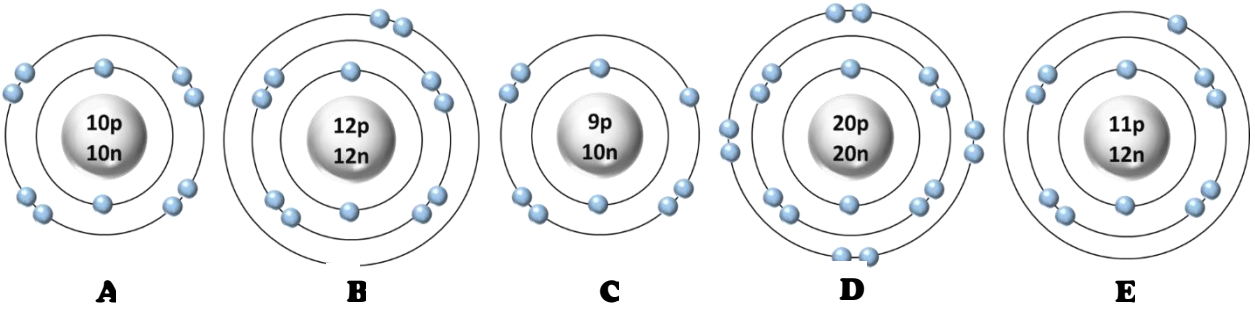
i. What happens to the number of valence electrons as you go down a group on the periodic table?
ii. What happens to the number of valence electrons as you go from left to right across a period?
iii. What happens to the number of energy levels as you go down a group on the periodic table?
iv. What happens to the number of energy levels as you go from left to right across a period?
v. Draw a Lewis structure for a Cl atom.
vi. Draw a Bohr diagram for the Cl atom. (Draw above)
vii. In this lab we will be talking about atomic radius.
   a. Look up the atomic radius of Cl on Table S: _____
   b. On your Bohr diagram draw an arrow to represent the radius of the Cl atom.

Note: Refer the link for continuation.

https://www.pittsfordschools.org/site/handlers/filedownload.ashx?moduleinstanceid=2613&dataid=18101&FileName=pogil%20-%20periodic%20trends%20_rhsd_.docx

2.10 Appendix 9(i)

Worksheet on the Noble Gas



1) Classify the above elements A-E into different groups in modern periodic table.
2) Which of these elements are least reactive? Give reason.

3) Name a noble gas used in:

a. Aeroplane tyres: _____

e. Miner cap lamp: _____

b. Advertising board: _____

c. Electric bulb: _____

d. Radiotherapy: _____

2.11 Appendix 9(j)

Experiment to Determine the Rate of Reaction

Aim: To determine the rate of reaction.

Materials required: dilute HCl, test tubes, magnesium ribbon, stop watch, weighing machine, test tube holder, etc.

Safety and Precaution:

- Handle the acid safely - use dropper for transferring acid from its container to test tube.
- Wear goggles to protect your eyes from acid spill and harmful gases.
- Do not move around carrying acid in dropper.
- Use test tube holder while transferring acid from its container to test tube.

First aid

- In the case of acid spill on your skin or eye, flush the spilled area with sufficient amount of water.
- Report the incident to your teacher immediately.

PROCEDURE

1. Take 20ml of hydrochloric acid in a clean and dry test tube.
2. Weigh 4g of magnesium.
3. Drop the magnesium ribbon into the test tube and start the stopwatch.
4. Stop the stopwatch when the magnesium has finished dissolving and note the time.

2.12 Appendix 9(k)

Worksheet on Rate of Reaction

A chemist wishes to determine the rate of reaction for burning of magnesium in air. The equation for the reaction is:

$$2Mg_{(s)} + O_{2(g)} \rightarrow 2MgO_{(s)}$$

The following data were obtained when magnesium was burned in air:

Expt.	Time	Mass of Mg + O_2	Mass of MgO
1.	0s	80g	0g
2.	2s	75g	5g
3.	4s	70g	10g
4.	6s	65g	15g
5.	8s	60g	20g
6.	10s	55g	25g

a. Calculate the rate of reaction in grams of reactants consumed per second.
b. Calculate the rate of reaction in grams of magnesium oxide produced per second.
c. How long does it take for the reaction to complete?

2.13 Appendix 9(l)

Worksheet on Energy Transfer

Bases on the experimental activity answer the questions that follow.
1) Complete the table given below:

Reaction in work station	Prediction (Heat absorbed or heat released)	Temperature of water (initial temperature)	Temperature of solution (final temperature)	Change in temperature (Final temperature - Initial temperature)	Inference
W1 ($NaOH + H_2O$)					
W2 ($NH_4Cl + H_2O$)					

2) Classify the above reactions as exothermic or endothermic.

3) Write down the thermochemical equation for above reactions.

4) Give 3 day-to-day examples each for endothermic and exothermic reactions.

5) Identify the type of thermochemical equations as endothermic or exothermic:

(i) $CaO + H_2O \rightarrow Ca(OH)_2 + Heat$ _____

(ii) $CaCO_3 \rightarrow CaO + CO_2 - Heat$ _____

(iii) $2NaOH + 2HCl \rightarrow 2NaCl + 2H_2O + Heat$ _____

(iv) $Mg + 2HCl \rightarrow MgCl_2 + H_2 + Heat$ _____

(v) $N_2 + O_2 \rightarrow 2NO - Heat$ _____

2.14 Appendix 10(a)

Worksheet on Mole Concept

Title: Understanding the Mole Concepts

The dozen is a unit of counting objects.

1. How many eggs are there in a dozen egg?

2. How many pencils are in a dozen pencil?

Similarly, the mole (mol) is a unit for counting objects. It is especially useful for counting tiny objects like atoms, molecules, ions, and formula-units.

1 mole of objects = 6.023×10^{23} objects `

3. How many atoms of copper are in 1 mole of copper?

4. How many molecules of water are in 1 mole of water?

5. How many atoms of zinc are in 10.2 moles of zinc?

6. Find out how many moles of water contain 1.51×10^{24} molecules of water.

7. Estimate the number of times a human heart beats during a lifetime of 80 years. Express this number in moles.

Molar Mass

1. What does amu stand for?

2. What is the molar mass of sodium chloride?

3. How are the molar masses of molecules determined?

4. Calculate the molar mass of water molecules.

5. What is the gram-molecular mass of sulphur dioxide?

6. What is the gram-molecular mass of ammonia (NH_3)?

One mole of any gas at STP occupies the volume of 22.4 L, which is known as Molar volume.

1 mole of objects = 6.023×10^{23} objects

7. Calculate the volume occupied by 1 mole of O_2 at *STP*

8. Calculate the volume occupied by 4.4 g of CO_2 at *STP*

9. Equal volume of gases would contain equal number of …… at *STP.*

10. Calculate the number of molecules present in 11.2 litre of sulphur dioxide at *STP?*

11. How is counting a truckload of pennies like counting the atoms in 10.0 g of aluminium? How is it different?

2.15 Appendix 10(b)

Worksheet on Transition Elements

1. Write down the electronic configuration of the following transition elements:
   a) V
   b) Co
   c) Cu
   d) Ni

2. Give two physical properties and two chemical properties of transition metals:

3. What is the definition of a transition metal?

4. Give two rules that are usually followed when working out electronic configurations?

5. Why is zinc not a transition metal?

6. Describe how the electronic configuration of Chromium differs from expectation and explain why this is.

7. Describe how the electronic configuration of copper differs from expectation and explain why this is.

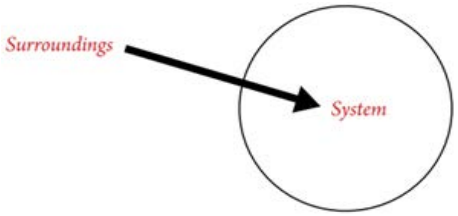
2.16 Appendix 10(c)

Activity on Enthalpy Change

Case ONE for enthalpy

1. Measure out 100 mL of water in a clean 150-mL beaker. Once again, label the "system" and the "surroundings" in the diagram below.
2. Place the beaker on your paper in the region labeled "system" below, then
3. measure the temperature of its contents with a thermometer and record.
4. Add 5.0 g of ammonium chloride or ammonium nitrate.
5. While holding the beaker at its base, stir, and make and record your observations, including the final temperature of the mixture.
6. Your hand at the base of the beaker can be considered part of the surroundings. Was thermal energy transferred to your hand from the beaker, or away from your hand to the beaker?

   Since my hand feels cooler, thermal energy is being transferred from my hand to the beaker.
7. Label the diagram below with an arrow, showing the direction of the transfer of thermal energy. Is thermal energy transferred from the surroundings to the system or from the system to the surroundings?



8. Is the change endothermic or exothermic?

   Endothermic
9. Is ΔH of the system positive or negative?

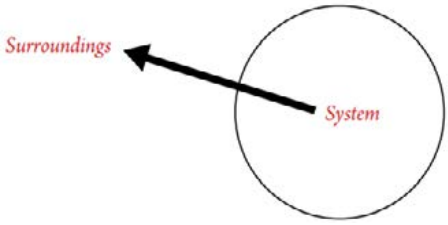
   Positive

Note: Repeat the same procedure with calcium chloride

Case TWO for enthalpy

1. Measure 100 mL of water in a clean 150-mL beaker.
2. Place the beaker in the "system" below, and measure and record the temperature of its contents. Add 5.0 g of calcium chloride.
3. While holding the beaker at its base, stir, and make and record your observations, including the final temperature of the mixture.

4. Was thermal energy transferred to your hand from the beaker, or away from your hand to the beaker?
   Since my hand feels warmer, thermal energy is being transferred from the beaker to my hand.
5. Label the diagram below with an arrow, showing the direction of the transfer of thermal energy. Is thermal energy transferred from the surroundings to the system or from the system to the surroundings?



6. Is the change endothermic or exothermic?
   Exothermic
7. Is ΔH of the system positive or negative?
   Negative

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