9

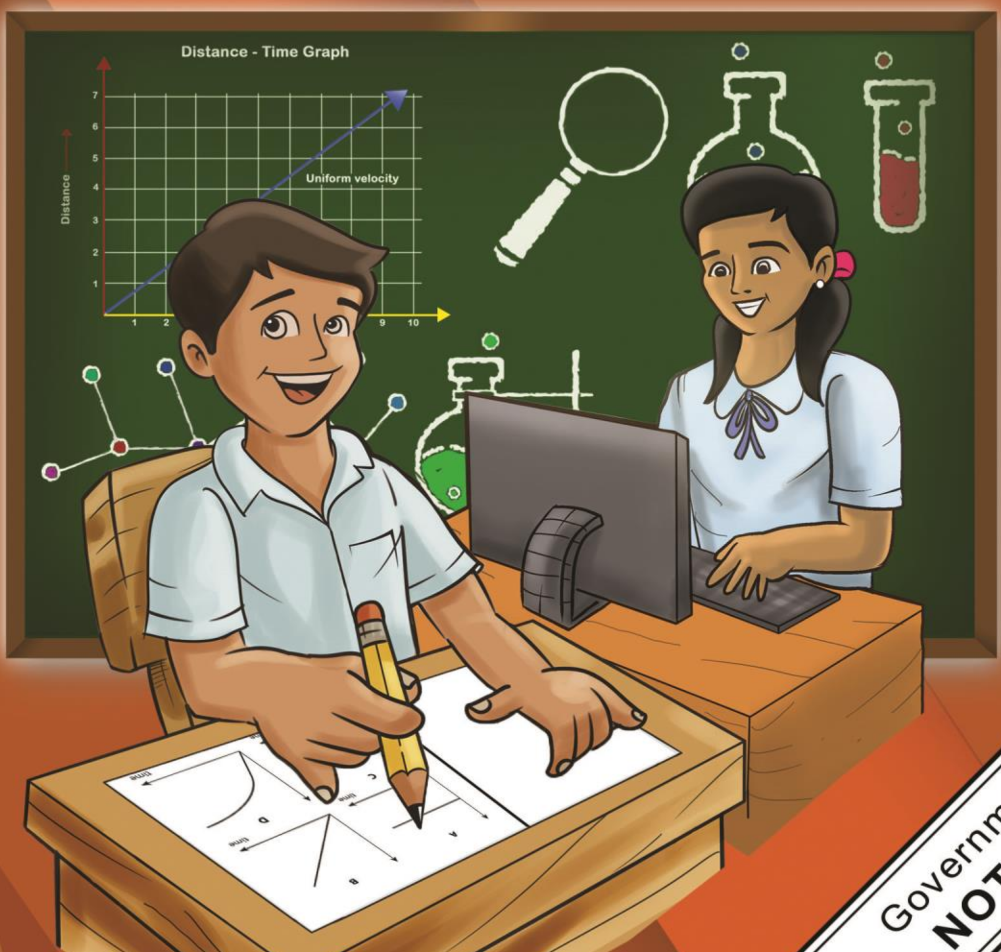
NATIONAL LEARNING CAMP

DepED
DEPARTMENT OF EDUCATION

Science

Consolidation Learning Camp

Lesson Plans



Consolidation Learning Camp
Lesson Plans

Science Grade 9

Weeks 1 to 3

Contents

Dear Reader
Every care has been taken to ensure the accuracy of the information provided in this Booklet. Nevertheless, if you identify a mistake, error or issue, or wish to provide a comment we would appreciate you informing the **Office of the Director of the Bureau of Learning Delivery** via telephone numbers (02) 8637-4346 and 8637-4347 or by email at bld.od@deped.gov.ph

Thank you for your support.

National Learning Camp Overview

Overview

The National Learning Camp (NLC) aims to enhance student and teacher learning through interactive lessons based on prior educational content. The program focuses on consolidating student knowledge, updating and expanding teacher expertise, and applying research-based strategies to improve teaching-learning outcomes

The NLC offers grade-level review lessons that are directed by the teacher and designed to be highly interactive between:

(i) students with their teacher; and
(ii) students with their peers.

The Camp lessons are grounded in the 'Science of Learning' framework, focusing on cognitive research and practical applications to enhance learning outcomes. Lessons are structured to reinforce foundational knowledge and skills, involve real-world problem-solving activities, and encourage higher-order thinking. The Camps also offer teachers opportunities for reflection and professional growth, encouraging the adoption of new teaching approaches and the extension of student learning through systematic review and application of knowledge.

Design Basis

A strength of the design is the focus on both student and teacher learning. The intentions and expectations of the NLC are for:

- students to consolidate and enhance their thinking in topics already covered.
- teachers to update, strengthen and expand their subject knowledge in ways that encourage students to be involved in learning activities at different levels including those considered as higher-order thinking skills.
- teachers to enhance their pedagogical practices by focusing on selected skills, which include 21^{st}-century skills.

Under the framework of 'Science of Learning', evidence-based research is used as guide in teaching and learning decisions around cognition research and features of a learning brain such as working memory demands, cognitive load, valuing errors, and domain specific skills. This framework highlights a *learning-focused approach* where teachers go beyond what might be considered current practice in the Philippines and incorporate brain-based ideas and approaches, including 21^{st}-Century skills, to make teaching more effective in enhancing learning for all.

To further support this direction, teachers are provided with resources, time, and the opportunity to further enhance their skills, knowledge and understanding of teaching and learning process. The review lessons are designed to apply subject content already encountered by students. Because of this, lessons do not contain repetitive, routine questions of a particular subject aspect.

Review lessons

The review lessons are based on content already encountered by students in their current grades. All lessons *involve an exploration of ideas, concept, and content*. The purpose of the review lessons is two-fold:

(i) to establish in students a stronger basis for future learning development (before enrolling in a new Grade after the summer break); and

(ii) to enable teachers to strengthen and enrich their teaching practice in a research-based, learning-focused professional program (before a new academic year).

The primary focus of the review lessons concerns revising, clarifying, and then applying previously taught subject content with real-world problem-solving and/or comprehension activities. Each lesson begins with a focused content review and clarification of material needed in the lesson to come. For students, this initial review enables them to practice retrieving and practicing important basics relevant to the lesson to come.

For teachers, this information is designed to help determine learners' subject background knowledge and skills relevant to the lesson as well as help teachers identify where to build on previous learning. This approach is different from 'teaching' students anew as if they have not been taught previously.

Lesson Overview

All lessons in each of the three subjects, English, Mathematics, and Science, contain five components. These are 1. Short Review, 2. Purpose/Intention, 3. Language Practice, 4. Activity and 5 Conclusion.

Timing

Approximate component timing is indicated as advice to guide the teacher in pacing the lessons. Time management involves:

- moving through components at a pace that is appropriate for learners;
- ensuring that all components are completed in a timely, efficient, and constructive manner.

Research on student-learning quality and time is related through student time-on-task. Time-on-task refers to when students are actively involved (engaged) in some aspect of the learning process. The suggested times for each component are intended to maximize the time available for student involvement. This will encourage the student and teacher to work efficiently, timewise, through the lesson without jeopardizing the importance of student activities such as:

- answer routine and non-routine questions,
- respond to verbal questions and explanations,
- interpret and use appropriate terminology,
- discuss aspects with their peers,
- explain or justify his/her approaches and thinking,
- work productively on their own, and
- listen carefully to the teacher or peers.

Establishing what is on-task time is more problematic when the teacher talks and students passively listen, such as in didactic teaching. With such an approach it is difficult to determine whether students are listening or even paying attention. Often in lessons identifying time-on task can also be problematic in case of problem-solving or intense reading and comprehension. Here, student activity is often subtler and more cerebral as students need to think quietly by themselves.

Ultimately, however, the time allocated to components will be determined by learners' needs and strengths. There needs to be practical limits on the duration of the components to prevent major disruption to lessons which can have a detrimental impact on student learning. Often, teachers should not expect too much learning to occur in an initial meeting of unfamiliar content. It is repeated exposure associated with elaboration, addressing errors, and deliberately practicing key aspects where most learning occurs.

When times are allocated appropriately, and students become familiar with the approach and teacher expectations, concept development and student skill levels are improved as well as student engagement.

Note: Care needs to be exercised in determining what engagement means. Engagement is clearer when **students are learning** through answering questions, writing, discussing, and reading.

Key Ideas and Questioning

Critical aspects of the NLC for the teacher include questions related to learning areas, based around a *key idea*. The questions are offered at different levels of difficulty involving lower- to higher-order thinking, starting with questions of modest complexity up to those that require more developed reasoning.

In the lessons, students are provided with opportunities to practice solving non-routine questions to help improve their conceptual understanding by applying known content to subject-related problems.

Teacher Reflection

Teacher reflection on the lessons offers important insights to stimulate teachers and their peers to enhance their practice and the learning of their students. This includes:

- new teaching approaches encouraged by lesson components that can contribute in different ways to student learning and lesson success;
- the use of review lessons that help review learned material and extend student abilities in problem-solving by utilizing known information; and
- a focus on student concept and skill acquisition, pedagogical approaches, student errors, time-on-task, deliberate practice and working memory demands.

Enhancement and Consolidation Camps

The Enhancement Camp and the Consolidation Camp offer students the chance to review their subject background knowledge by consolidating previously taught material. The intention is:

- for students to have opportunities to review past work and to practice applying this knowledge of concepts and ideas through grade-related sets of questions of developing difficulty; and
- for teachers to follow the given format of components with some flexibility to adjust parts of a lesson to meet the learning needs of students in their class, particularly, if students are having difficulties.

Camp Differences

Lessons for students in either the Enhancement Camp or Consolidation Camp, the materials, including the lesson plans and the sets of questions, are, on the surface, the same. These questions range from those of modest difficulty to those that require more insight and more knowledge and understanding.

There are important reasons for both Camps sharing the same content. Exploring and answering these question sets has value to students from both Camps, albeit in different ways. It enables students to work through a range of ideas on their own before hearing from their peers and teacher concerning the same questions – a very rich learning environment. Also, similar questions mean that expectations for students in both Camps is not limited and students have the same growth potential.

The difference between Camps concerns the teaching focus, which is related to the breadth and depth of conceptual knowledge of students. It is anticipated that based on student performance within a lesson, the teacher will decide whether the class needs more practice and discussion of straightforward questions or whether extension material is more appropriate for the class.

In particular, questions marked as **Optional** (typically high-order questions) are more likely to be addressed in the Enhancement Camp than the Consolidation Camp, but not exclusively. It is the teacher who decides whether to include 'optional' questions and this will depend on student learning success and understanding at that time.

If Optional questions are not used, teachers would spend that time productively. This includes reinforcing the concepts by increasing the focus on student errors and/or increasing student-student, and student-class-directed conversations.

Lower- and Higher-order Skill and Knowledge Development

In all learning, lower-order thinking is a prerequisite for higher-order skills and knowledge development. Many students are disadvantaged in their attempts to move forward in their learning through a lack of practice and conceptual development of needed lower-order skills, knowledge and understandings. Hence, *all* students benefit from a stock-take on relevant lower-order skills from previously addressed content. This helps establish a basis upon which student learning should be built.

In both the Enhancement and Consolidation Camps important lower-order content skills, knowledge and understandings are re-visited at the beginning of each lesson. This helps ensure that potential learning obstacles are made visible to the student and the teacher. It also means that some errors in understanding or misconceptions are identified. This information is important to teachers in helping all students move forward regardless of their achievement levels.

As many questions posed are about applying content already encountered to a new problem, students have the opportunity to use their current knowledge, skill and understanding practically at their level, further developing their conceptualization and understanding of the subject matter.

Both Camps offer students the opportunity to improve their learning and conceptual development through a stepped approach that involves:

(i) reminding students of relevant lower-order skills through practice,
(ii) having students use and discuss their knowledge in sets of graded questions with an emphasis on straightforward questions,
(iii) expecting students to apply their knowledge leading to more breadth in learning,
(iv) beginning an initial focused practice on higher-order skill development.

The approach advocated to solve problems or comprehend passages extend student learning beyond simple repetitive exercise sets. For these students the teaching part of the lesson requires teachers to review closely student solution attempts through student explanation, discussion and questioning of fundamental aspects of topics that are typically found in the earlier questions. Teachers should be sensitive to students' self-perceptions here as they may meet the ideas presented in the lessons, maybe after many failures with these concepts in the past.

Nevertheless, these students should become aware of the more difficult questions as teachers allow them to consider links or connections between concepts previously taught. There is great value in problem-solving for students to have time to read the problem and then be able to indicate in their own words, what the problem is about.

Finally, students in the Enhancement and Consolidation Camps become aware of what their students know, where it is progressing and how to build on student skills and knowledge. Teachers need to be nurturing and supportive of this development and continually look for evidence of success and growth. Teachers also need to encourage students to persist, continue to practice individual aspects, and use any mistakes/errors they make as an opportunity to learn more. These are important features of a successful learning journey.

Lesson Components: Short Overview

Lesson Component 1 (Lesson Short Review)

Component 1 offers teachers the chance to:

- settle the class quickly;
- review previously encountered information;
- address previous content in the form of a few targeted questions that are *relevant to the current lesson;*
- note what students already know;
- elicit answers from the class to reinforce the important content needed for the lesson; and
- address briefly issues that may arise.

The questions set for the Short Review section of a lesson are designed to *remind* students of the knowledge and skills developed when first studying the topic area, which is relevant to the lesson.

Lesson Component 2 (Lesson Purpose/Intention)

Component 2 offers teachers a chance to acquaint students with the purpose/intention of the lesson. It is valuable if students see a link here with their prior knowledge or experience, especially if the teacher can connect it to the responses and levels of student understanding evident in Component 1.

In addition, this component is an appropriate time to address what students might expect/aim to achieve, i.e., their lesson goal(s). Teachers should clarify, in clear language, the learning intention for the students as well as what success will look like. (Note**:** The degree of success or partial success of student learning in the lesson should occur as part of Component 5.)

Lesson Component 3 (Lesson Language Practice)

Component 3 concerns language use – speaking, hearing, listening, and comprehending. The focus is on words or phrases that are to be used in the lesson.

The language practice suggested has been identified by considering the whole lesson and identifying those words/phrases that have the potential to cause difficulties for students through speech, listening, or understanding. Typically, the language identified is restricted to less than 6 words/phrases so that there is enough time to use a variety of approaches of practice within the time available.

Lesson Component 4 (Lesson Activity)

Component 4 has three aspects, 4A, 4B, and 4C.

In the case of the Learning Camp activity, Component 4 addresses the key idea for the lesson. It is about students applying known content to solve real-world problems. This requires students to interpret/understand the correct meaning of the 'stem', a stimulus, (such as a passage/text or diagram or the first part of the problem or story) before answering questions of differing degrees of complexity related to the stem.

Students are first presented with the stem in 4A and are given the time/chance to interpret its meaning. Then in 4B and 4C, two separate sets of questions related to the same stem are asked.

4A Reading and Understanding the Stem

4A involves understanding the language of the stem. The purposes here are for the teacher:

- to model fluent reading of the stem (first)
- to identify any unfamiliar language for the student (possibly addressed in Component 3)
- to read the passage or describe the figure, etc.
- to hear and experience fluency in reading the stem.

4B Solving the First Set of Questions

4B involves a set of questions associated with the stem. Students will need to refer to the stem as they prepare to answer the set of questions. Students write down responses or attempts at each question. Every student in the class must be expected to have a response to each question. It is expected and acceptable that students would make errors, which provides teachers with important information concerning students' learning needs. A critical procedural action here for teachers is the importance of all students starting on the same set of questions, *at the same time*.

When the students are finished, or sufficient time has been allocated, the teacher marks the questions. This can be achieved by student answers or approaches to the questions and by explaining or justifying their reasons. Time should be allocated to student discussion, explanation, and reasoning about answers.

4C Solving the Second Set of Questions

4C offers a new start for students regardless of how they performed in Component 4B. The structure is very similar to Component 4B, i.e., undertaking a new set of questions related to the same stem. In addition, the lesson structure allows a refresh as 4C presents a new starting point for the student. This structure also allows all students in the class to start a new activity at the same time.

This approach serves two purposes for teachers. *First,* it enables teachers to bring all students back together to proceed as a group with issues to be directed to and considered by every student at the same time. *Second,* it offers teachers a way to extend their students' problem-solving practice where *a different set of questions* can be used with a single Stem. This is an efficient way to incorporate more problem-solving or comprehension practice on specific content into a lesson.

Lesson Component 5 Lesson Conclusion

Component 5 has a high metacognitive aspect for students – students thinking about their thinking – which can be further enhanced by teacher modeling. Component 5 is designed to offer a student-focused overview to the main intentions of the lesson. In particular, the focus is on helping students reflect on their progress and achievement (or partial achievements) of the lesson intention as well as their understanding development during the lesson.

It builds on comments from Component 2 about teacher expectations. There is a chance here to confirm student progress during the lesson. A teacher may use a diagram, picture or some aspect of the lesson as a catalyst to stimulate student discussion and reflection.

NOTE: A fuller description of the Components and features of the lessons is provided in the **Learning Camp – Notes to Teachers Booklet.** It is recommended that these notes are read and discussed by teachers as they provide a further for basis to understanding the structure of lessons and the pedagogy.

Science Grade 9 Lesson No. 1

The Bohr Model

Key Idea

The structure of the atom includes subatomic particles, their symbol, mass, charge, and location.

Component 1: Short Review (Time: 7 minutes)

- Ask learners to answer the following questions on their worksheets.

  Q1. According to Bohr's atomic model, what is the structure called at the center of the atom?

  Q2. What are the particles inside the center called?

  Q3. What other particles are important in an atom and where are they located?

- Ask learners to share their answers and offer positive feedback. Read out a sample answer (from a student or the provided examples) for everyone to listen to and take notes on.

Sample answers:

Q1. The center of the atom is called the nucleus.

Q2 The particles inside the center are protons and neutrons.

Q3. The other important particles are electrons, and they are in orbits known as energy shells around the nucleus.

Component 2: **Lesson Purpose** (Time: 3 minutes)

This lesson is about a model of the structure of the atom as described by Niels Bohr and the limits of that structure.

The lesson may also help learners understand that scientists sometimes draw diagrams and use models to represent what cannot be seen with the naked eye.

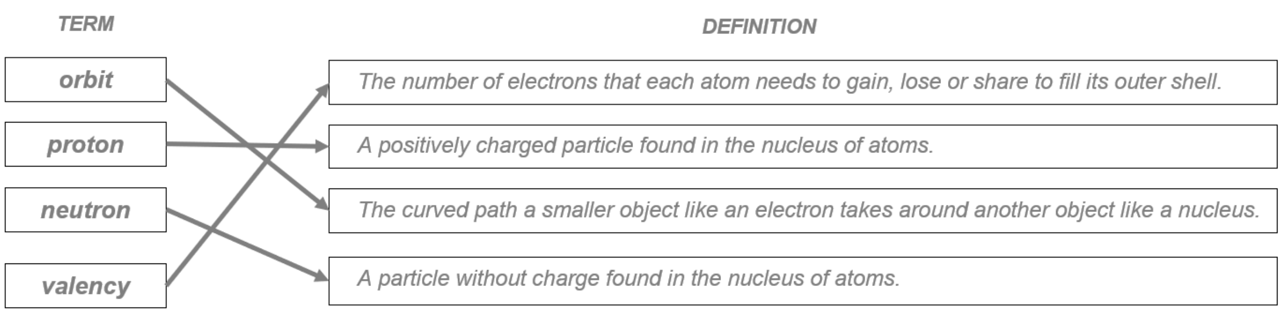
Component 3: Lesson Language Practice (Time: 5 minutes)

- Read out difficult or unfamiliar words or phrases and ask the learners to read them to themselves and then out loud as a class, e.g.:

orbit; protons; neutrons; valency

- Ask learners to complete the matching task provided in their worksheet by using arrows to match each scientific **Term** with its correct **Definition** [A solution is provided below for the teacher]. Ask learners to provide answers and discuss where needed.

Sample answer.

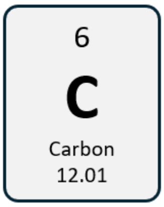


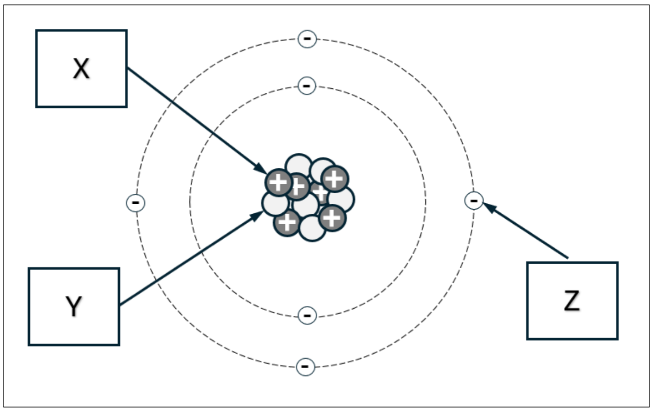
Component 4*:* Lesson Activity (Time: 25 minutes)

Component 4A

- Refer learners to the main lesson stimulus pointing out that it includes *symbolic representations of the structure of atoms as well as two short paragraphs of text.*
- Read out the written text. Ask the learners if there are any words that they are not familiar with and give descriptions of any words that may be unfamiliar or confusing.

The Bohr Model of an atom of Carbon





Jose is in Grade 9. One day he said to his parents that his teacher had been talking about the structure of the atom in class, so he decided to research what he could find out for himself. He put together the following paragraph from several sources.

Niels Bohr

In 1913, Niels Bohr proposed a model for the structure of an atom based on the work of Ernest Rutherford about the nucleus of atoms and Max Planck's quantum theory. Bohr suggested that the central heavy positive nucleus contains protons and neutrons and that the negatively charged electrons moved around the nucleus in circular paths called orbits. Although Bohr's model has been shown to be inaccurate in terms of the electron energy levels or shells it is still used today as an introduction to the Atomic Theory. The Quantum Mechanical Model of the Atom is currently accepted as more accurate. The symbols used in chemistry for the subatomic particles are neutrons $\mathbf{n^o}$, protons $\mathbf{p^+}$, electrons $\mathbf{e^-}$**.**

Component 4B

- Read out the following questions and ask learners to answer in the space on their worksheet.

Q1. How many protons are there in the diagram?

Q2. What is the name of the type of particle labeled Y, and how many are there in the diagram and what charge do they carry?

Q3. What is the name of the type of particle labeled Z, and why are there the same number as there are protons in the diagram, and what charge do they carry?

- Observe learners' answers. Ask the learners to share their answers. Give positive feedback. Select a good sample answer for all learners to write down. This may come from the learners or the following sample answer.

Sample answers:

Q1. There are 6 protons in the nucleus.

Q2. The particles labeled Y are neutrons, there are 6 of them and they carry no charge.

Q3. The particles labelled Z are electrons and there are 6 in orbit around the nucleus, and they carry a negative charge, resulting in the atom being neutral in charge.

Component 4C

- Read the following questions and ask learners to answer in the space on their worksheet.

  Q1. Bohr based his theories of the structure of an atom on two other scientists. Name the two scientists.

  Q2. What is the electron configuration for an atom of Carbon?

  Q3. **(Optional)** Why is the structure of the atom so important in chemistry?
- Observe learners' answers. Ask the learners to share their answers. Give positive feedback. Ask the learners to volunteer their answers, giving positive feedback. Select a good sample answer for all learners to write down. This may come from the learners or the following sample answer.

Sample answers:

Q1. The two scientists on whose work Niels Bohr based his own atomic theory were Ernest Rutherford and Max Planck.

Q2. The electron configuration for an atom of Carbon is represented as $1s^2\ 2s^2\ 2p^4$

Q3 The structure of the atom is important in Chemistry because the electrons in the outer shell of an atom (the valence electrons) are the electrons that form bonds with other atoms and take part in a chemical reaction between atoms of elements and compounds.

Component 5: Lesson Conclusion (Time: 5 minutes)

The focus of this lesson was on the structure of atoms.

- Ask learners to answer the following questions either by class discussion or by writing the answers in their worksheets.

  Q1. Has this lesson helped you to better understand what an atom is? If so, how?

  Q2. Which questions were easy to answer – the ones in Component 4B or Component 4C? Why?

Let learners know that good learners reflect on their learning.

REMINDER: Collect learner worksheets to review and analyze learner's knowledge and understanding.

Science Grade 9 Lesson No. 2

More About Atoms

Key Idea

The specific structure and position of the subatomic particles in the atoms of an element determine the characteristics of that element.

Component 1: Short Review (Time: 7 minutes)

- Ask learners to answer the following questions on their worksheets.

  Q1. What is the overall charge of an atom?

  Q2. What are the positive particles in an atom called and what are the negative particles called?

  Q3. Are all the atoms of all the elements the same? Give examples?

  Ask learners to share answers. Give positive feedback. Read out a sample answer (from a student or the provided examples) for everyone to listen to and take notes on.

Sample answers:

Q1. The overall charge of an atom is neutral.

Q2. The positive particles are protons, and the negative particles are electrons.

Q3. No, all the atoms of all the elements are different, that is the atoms of hydrogen are different from the atoms of oxygen or the atoms of carbon etc.

Component 2: **Lesson Purpose** (Time: 3 minutes)

This lesson is about how atoms of one element are different from the atoms of another element.

The lesson may also help learners to better understand the concept of elements and compounds.

Component 3: Lesson Language Practice (Time: 5 minutes)

- Read out difficult or unfamiliar words or phrases and ask the learners to read them to themselves and then out loud as a class, e.g.:

  Aluminum; Carbon; Lead

- Ask the learners to practice saying the words.

The meaning of possibly unfamiliar words is described in the stimulus.

Component 4*: Lesson Activity* (Time: 25 minutes)

Component 4A

- Refer learners to the main lesson stimulus pointing out that it includes *representations* (*as well as two paragraphs of text) of elements that help explain the differences in their properties.*
- Read out the written text. Ask the learners if there are any words that they are not familiar with and give descriptions of any words that may be unfamiliar or confusing..

WHAT'S THE DIFFERENCE?

Look carefully at the pictures above and see how one object differs from the others. Each of these objects is made from a different element. Some are shiny, some have color, some are hard, and some are soft. We use these different objects for different purposes based on these properties. The reason they have different properties is that their atoms are slightly different, they have different number of protons in their nucleus and therefore different numbers of electrons in orbits around the nucleus.

Gold is a metal that has an atomic number of 79 and is used to make jewelry and other precious items.

Lead is a metal with atomic number 82, it is not very shiny and it is used for weights, in batteries and paint.

Carbon is a non-metal with atomic number 6 and occurs in nature as diamond and graphite they look very different from one another.

Aluminum is a shiny metal, with an atomic number of 13 and is used to make cooking utensils and roofs on houses.

Component 4B

- Read the following questions and ask learners to answer in the space on their worksheet.
  Q1. Can you name one thing other than what is in the pictures, that is often made of Gold?
  Q2. Does Aluminum have more protons than Carbon? If so, how many?
  Q3. Things that are made of lead are often heavy, can you suggest why?
- Observe learners' answers. Ask the learners to share their answers. Give positive feedback. Select a good sample answer for all learners to write down. This may come from the learners or the following sample answer.

Sample answers:

Q1. *Gold watch, chain many possible answers.*
Q2. *Aluminum has seven more protons than Carbon.*
Q3. *Maybe because each of its atoms has a lot of protons in it, so then maybe anything made of Lead would be heavy.*

Component 4C

- Read the following questions and ask learners to answer in the space on their worksheet.

  Q1. If Magnesium has 12 protons in its nucleus, how many electrons does it have in orbits around it?

  Q2. What are the symbols for protons, neutrons, and electrons?

  Q3. **(Optional)** How many electrons are there in the outer shell of a Magnesium atom, and what would you predict its valency to be and why?

- Observe learners' answers. Ask the learners to share their answers. Givepositive feedback. Ask the learners to volunteer their answers, giving positive feedback. Select a good sample answer for all learners to write down. This may come from the learners or the following sample answer.

Sample answers:

Q1. It has 12 electrons in 3 electron shells.

Q2. Protons are ***p+***

Neutrons are n^0

Electrons are e^-

Q3 Magnesium has 2 electrons in its outer shell and therefore it has a valency of 2 and this is because atoms that have 1 ,2,3,4 electrons in their outer shell have a valency equal to the number of electrons but atoms with 5,6,7,electrons in their outer shell have a valency of 8 minus the number of electrons in the outermost shell e.g. Chlorine has 7 valence electrons so it has a valency of 8 minus 7 which is 1.

Component 5: Lesson Conclusion (Time: 5 minutes)

- The focus of this lesson was on the differences between atoms.
- Ask learners to answer the following questions either class discussion or by writing the answers in their worksheets.

  Q1. Has this lesson helped you to better understand the differences between atoms? If so, how?

  Q2. *Which questions were easy to answer – the ones in Component 4B or Component 4C? Why?*

Let learners know that good learners reflect on their learning.

REMINDER: Collect learner worksheets to review and analyze learner's knowledge and understanding.

Science Grade 9 Lesson No. 3

Elements

Key Idea

In chemistry, elements are identified as pure substances.

Component 1: Short Review (Time: 7 minutes)

- Ask learners to answer the following questions on their worksheet.

  Q1. Is a mixture a pure substance?

  Q2 Air contains the elements oxygen and nitrogen. Is it a mixture?

  Q3. Why is Hydrogen a pure substance?

Ask learners to share their answers and offer positive feedback. Read out a sample answer (from a student or the provided examples) for everyone to listen to and take notes on.

Sample answers:

Q1. No, a mixture, by definition, contains more than one pure substance.

Q2. Yes, it is a mixture of two elements.

Q3. Hydrogen is an element, and it contains only one type of atom.

Component 2: **Lesson Purpose** (Time: 3 minutes)

This lesson is about the definition of a pure substance in chemistry using elements as an example.

The lesson may also help learners to better understand how to extract information from tables in chemistry

Component 3: Lesson Language Practice (Time: 5 minutes)

- Read out difficult or unfamiliar words or phrases and ask the learners to read them to themselves and then out loud as a class, e.g.:

pure substance; substance; element

- Ask the learners to practice saying the words.
- Ask learners to select one of the words above and write two sentences. One with an everyday meaning and another using the same word with a scientific meaning.

Sample answers:

A teacher told one of her learners that her answer had no ***substance.***
A ***pure substance*** *in chemistry is matter which has specific composition and properties.*
That book I read had all the ***elements*** *of a great love story.*
An ***element*** *has only one kind of atom and cannot be broken down into simpler substances.*

Component 4*: Lesson Activity* (Time: 25 minutes)
Component 4A

- Refer learners to the main lesson stimulus pointing out that it includes *a table which provides information about some common elements.*
- Ask the learners if there are any words that they are not familiar with and give descriptions of any words that may be unfamiliar or confusing.

COMMON ELEMENTS

Name of element	Symbol	No of protons	Valence Electron	Valency	Where found	Common use
Hydrogen	H	1	1	1	Found combined with Oxygen, in the air and the sea.	The free element is used to make ammonia
Chlorine	Cl	17	7	1	Found combined with Sodium in the sea and in salt mines.	The free element is used as a disinfectant and as a cleaning agent
Carbon	C	6	4	4	Found as graphite, and diamond in the Earth's crust. Found combined with Oxygen, Hydrogen and Nitrogen in the human body.	It is used in inks and rubber. Combined with other elements has many purposes in the human body and in the atmosphere
Oxygen	O	16	6	2	The free element is found as a gas in the atmosphere and the ocean.	It is vital to the process of photosynthesis. It is vital to the process of circulation in mammals and birds
Aluminum	Al	13	3	3	Found combined with other elements as the ore bauxite in the Earth's crust.	It is used to make cans, window frames
Lead	Pb	82	4	4	Found combined with other elements e.g. in the ore galena in the Earth's crust.	It is vital to make weight belts, batteries
Calcium	Ca	20	2	2	Found combined with other elements as limestone or gypsum in the Earth's crust.	Hydroxyapatite is used for many purposes by the human body

N.B There are many other elements on Earth than those in the table above.

Component 4B

- Read out the following questions and ask learners to answer in the space on their worksheet.
  Q1. Which one of the above elements have you heard of before?
  Q2. Which other elements do you know about that are not in the table?
  Q3. Which of the above elements do you find the most interesting and why?
- Observe learners' answers. Ask the learners to share their answers. Give positive feedback. Select a good sample answer for all learners to write down. This may come from the learners or the following sample answer.

Sample answers:

Q1. Any one of the above 7 elements. Many possible answers. Most likely Oxygen, Aluminum, Lead
Q2. Helium, Magnesium, Nitrogen, Uranium, Lithium, Sodium, Iron, Copper, etc.
Q3. Lead because it is poisonous and has become such a problem in our everyday lives.
or
Carbon because carbon dioxide is so much part of our human body but in the atmosphere can become a problem.
or
The element Chlorine because, as sodium chloride, it is vital to so many living things but as the gas chlorine it is toxic, etc.

Component 4C

- Read out the following questions and ask learners to answer in the space on their worksheet.
  Q1. Which of the elements above occurs as a gas and as a free element in nature?
  Q2. Which element is found in abundance in the Earth's crust as the ore, *bauxite*, and which one is found as *galena*?
  Q3. **(Optional)** How many electrons are there in the outer shell of Carbon, Aluminum and Chlorine?

- Observe learners' answers. Ask the learners to share their answers. Give positive feedback. Ask the learners to volunteer their answers, giving positive feedback. Select a good sample answer for all learners to write down. This may come from the learners or the following sample answer.

Sample answers:

Q1. The element oxygen
Q2. The element aluminum is found as bauxite and lead is found as galena.
Q3. The outer shell pf carbon has 4 electrons, whereas the outer shell of Aluminum has 3 electrons and Chlorine only has 1. (Chlorine has 7 valence electrons)

Component 5: Lesson Conclusion (Time: 5 minutes)

- The focus of this lesson was about pure substances in chemistry using examples of many different elements, the lesson was also about retrieving information from tables.
- Ask learners to answer the following questions either by class discussion or by writing the answers in their worksheet.
  Q1. Has this lesson helped you to better understand the differences between atoms? If so, how?
  Q2. Has this lesson helped you to remember the names and symbols of common elements? If so, how?
  Q3. Which questions were easy to answer – the ones in Component 4B or Component 4C? Why?

Let learners know that good learners reflect on their learning.

REMINDER: Collect learner worksheets to review and analyze learner's knowledge and understanding.

Science Grade 9 Lesson No. 4

Chemical Compounds

Key Idea

Compounds are identified as pure substances in chemistry.

Component 1: Short Review (Time: 7 minutes)

- Ask learners to answer the following questions on their worksheet.

  Q1. Name a common compound that is used every day.

  Q2. If elements and compounds are both pure substances, then what is the difference between them?

  Q3. Why are compounds considered to be pure substances?

Ask learners to share their answers and offer positive feedback. Read out a sample answer (from a student or the provided examples) for everyone to listen to and take notes on

Sample answers:

Q1. Water is a common compound used every day. Sodium chloride is also used for preservation, food, and medicine.

Q2. The difference between an element and a compound is that an element is made up of only one kind of atom, but a compound is made up of two or more kinds of atoms bonded together.

Q3. Compounds are considered pure substances because they have a fixed composition and consistent properties throughout a sample.

Component 2: **Lesson Purpose** (Time: 3 minutes)

This lesson is about compounds as examples of a pure substance.

The lesson may also help learners to better understand the difference between elements and compounds.

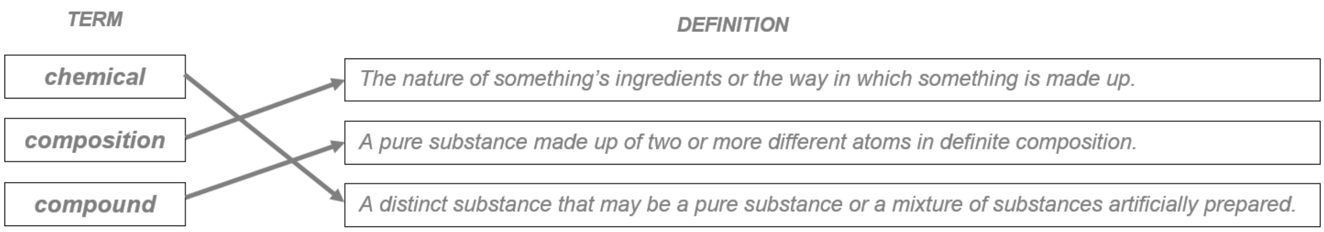
Component 3: Lesson Language Practice (Time: 5 minutes)

- Read out difficult or unfamiliar words or phrases and ask the learners to read them to themselves and then out loud as a class, e.g.:

  chemicals; composition; compound

- Ask the learners to practice saying the words.
- Ask learners to complete the matching task provided in their worksheet by using arrows to match each scientific **Term** with its correct **Definition** [A solution is provided below for the teacher]. Ask learners to provide answers and discuss where needed.

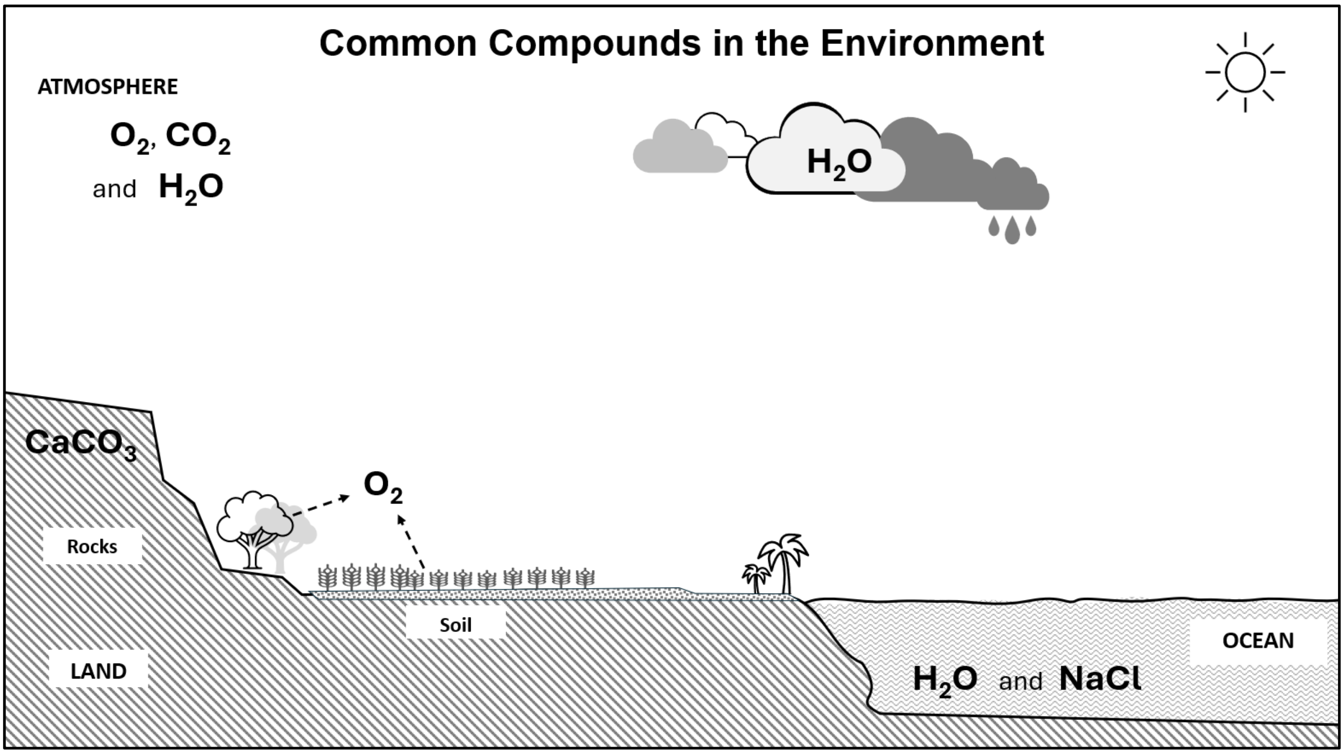
Sample answer:



Component 4*:* Lesson Activity (Time: 25 minutes)

Component 4A

- Refer learners to the main lesson stimulus pointing out that it includes *pictorial representations of a landscape that illustrates the presence of common compounds.*
- Look carefully at the diagram and work out what it is telling you. Ask the learners if there are any words that they are not familiar with and give descriptions of any words that may be unfamiliar or confussing..



Component 4B

- Read the following questions and ask learners to answer in the space on their worksheet.
  Q1. What is the chemical formula for water?

  Q2. What is the name of the compounds that have the chemical formula CO_2 and NaCl?

  Q3. If the common compound *salt* is found in the ocean, how come we can't see it?
- Observe learners' answers. Ask the learners to share their answers. Givie positive feedback. Select a good sample answer for all learners to write down. This may come from the learners or the following sample answer.

Sample answers:

Q1. The chemical formula for water is H_2O.

Q2. The names of the compounds are carbon dioxide and sodium chloride.

Q3. We can't see the salt because it is dissolved in the water.

Component 4C

- Read the following questions and ask learners to answer in the space on their worksheet.

  Q1. Where does a lot of the Oxygen in the air come from?

  Q2. Where does some of the water in the air come from?

  Q3. **(Optional)** What does the number 2 mean in the formula for water H_2O?

- Observe learners' answers. Ask the learners to share their answers. Give positive feedback. Ask the learners to volunteer their answers, giving positive feedback. Select a good sample answer for all learners to write down. This may come from the learners or from the following sample answer.

Sample answers:

Q1. The majority of oxygen production on Earth is attributed to phytoplankton in the oceans and terrestrial plants on land.

Q2. It comes from the evaporation of water from the oceans.

Q3. The numeral 2 in the formula for water means that for every atom of Oxygen there are two atoms of hydrogen.

Component 5: Lesson Conclusion (Time: 5 minutes)

- The focus of this lesson was on *compounds as examples of pure substances.*
- Ask learners to answer the following questions either by class discussion or by writing the answers in their worksheet.

Q1. Has this lesson helped you to better understand the difference between elements and compounds? If so, how?

Q2. Has this lesson helped you to remember the formulae for some common compounds? If so, how?

Let learners know that good learners reflect on their learning.

REMINDER: Collect learner worksheets to review and analyze learner's knowledge and understanding.

Science Grade 9 Lesson No. 5

The Chemical Nature of Earth

Key Idea

The periodic table is a useful tool to determine the chemical properties of elements.

Component 1: Short Review (Time: 7 minutes)

- Ask learners to answer the following questions on their worksheet.

  Q1. How many elements are currently included in the periodic table?

  Q2. How many groups and how many periods of elements are currently identified on the periodic table?

  Q3. Has the periodic table always included this number of elements?

Ask learners to share their answers and offer positive feedback. Read out a sample answer (from a student or the provided examples) for everyone to listen to and take notes on.

Sample answers:

Q1. There are 118 elements currently identified on the periodic table.

Q2. There are 18 groups and 7 periods in the modern periodic table.

Q3. No in the first version of the periodic table in 1869 there were only 63 elements known but scientists continuously discovered more elements that existed but were not identified. The periodic table has not always included the same number of elements. Over time, the periodic table has expanded as new elements have been discovered or synthesized in laboratories.

When Dmitri Mendeleev first developed the periodic table in the 1860s, it included only a fraction of the elements known today. Mendeleev's table had gaps where he predicted the existence of undiscovered elements based on the periodic patterns of known elements. Many of these predicted elements were later discovered and confirmed.

Since Mendeleev's time, scientists have continued to discover and synthesize new elements, expanding the periodic table. Elements beyond uranium (element 92) are typically synthetic and created in particle accelerators or nuclear reactors. As of my last update in January 2022, the periodic table includes 118 confirmed elements, with the discovery of elements beyond uranium occurring relatively recently.

Component 2: **Lesson Purpose** (Time: 3 minutes)

This lesson is about the variety of elements that make up the periodic table.
The lesson may also help learners to better understand how the periodic table is organized.

Component 3: Lesson Language Practice (Time: 5 minutes)

- Read out difficult or unfamiliar words or phrases and ask the learners to read them to themselves and then out loud as a class, e.g.:

  periods

- Ask the learners to practice saying the words.
  Sample definitions.
  In science, the word period is used to describe one complete horizontal set of the periodic table.

  In everyday terms the word period is often used to describe a section of time in history such as the Middle Ages, the Iron Age, and the Bronze Age.

Component 4*: Lesson Activity* (Time: 25 minutes)

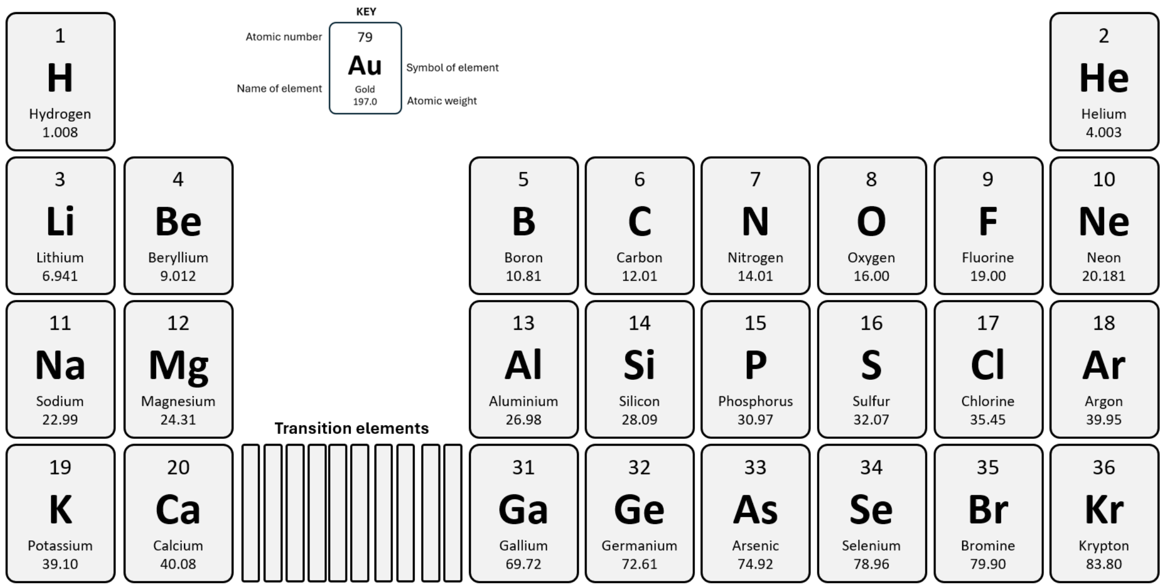
Component 4A

- Refer learners to the main lesson stimulus pointing out that it includes *an extract of the periodic table as well as some written text.*
- Read out the written text. Ask the learners if there are any words that they are not familiar with and give descriptions of any words that may be unfamiliar or confussing.

THE PERIODIC TABLE

Organization: *The elements in the periodic table are organized according to increasing atomic number. The vertical columns are called* ***Groups****; The horizontal rows are called* ***Periods****. As you move horizontally across a period, you are adding one more proton to the nucleus of the atom of that element. Elements with similar properties are arranged one above the other in vertical groups numbered from 1 to 18. There are 18 numbered groups but the 14 f block columns between groups 2 and 3 are not shown in the version below.*

Part of the **Periodic Table of the Elements**



Valency and outer electrons: *The elements within a group, for groups shown above all have the same number of electrons in their outer shell. So the group below Hydrogen all have 1 electron in their outer shell. The group below Beryllium all have 2 and so on.*

The number of electrons in each orbit is indicated in the following way, for example, for chlorine it is 2,8,7. This tells us that Chlorine is in the group below Fluorine and is in Period 3 of the periodic table because the 2,8,8,18, rule tells us the maximum number of electrons per shell. An atom has the same number of electron shells as the number of the period of the table it is in.

Atoms that have 1, 2, 3, or 4 electrons in their outer shell have a valency equal to the number of electrons, but atoms with 5, 6, or 7 electrons in their outer shell have a valency of 8 minus the number of electrons in the outermost shell, e.g. Chlorine has 7 valence electrons, so it has a valency of 8 minus 7, which is 1.

The elements in a group have similar physical and chemical properties because the chemical properties are dominated by the outermost electrons.

Component 4B

- Read the following questions and ask learners to answer in the space on their worksheet.

  Q1. Name an element in the same group as Arsenic on the periodic table.

  Q2. How many protons do elements Silicon and Sulfur have in their nucleus.

  Q3. What is the atomic number of Magnesium?

- Observe learners' answers. Ask the learners to share their answers. Give positive feedback. Select a good sample answer for all learners to write down. This may come from the learners or the following sample answer.

Sample answers:

Q1. Nitrogen or Phosphorous or Antimony, or Bismuth.

Q2. Silicon has 14 and Sulfur has 16.

Q3. The atomic number for Magnesium is 12.

Component 4C

- Read the following questions and ask learners to answer in the space on their worksheet.

  Q1. How could you work out the atomic number of an element?

  Q2. Why does Lithium have a valency of 1?

  Q3. **(Optional)** Explain why Oxygen has a valency of 2 but has 8 protons in its nucleus?
- Observe learners' answers. Ask the learners to share their answers. Give positive feedback. Ask the learners to volunteer their answers, giving positive feedback. Select a good sample answer for all learners to write down. This may come from the learners or the following sample answer.

Sample answers:

Q1. The atomic number is equal to the number of protons in the nucleus.

Q2. Lithium has a valency of one because it has 2 electrons in its first shell and then just one in the next or the outside shell. It is also in the same group as sodium which has a valency of 1.

Q3. Oxygen has a valency of two because it has 6 electrons in the outer shell and therefore its valency would be determined by saying 8 minus 6 is 2.

Component 5: Lesson Conclusion (Time: 5 minutes)

- The focus of this lesson was on the arrangement and significance of the periodic table.

- Ask learners to answer the following questions either by class discussion or by writing the answers in their worksheet.

  Q1. Has this lesson helped you to better understand the arrangements of the elements in the periodic table? If so, how?

  Q2. Which questions were easy to answer – the ones in Component 4B or Component 4C? Why?

Let learners know that good learners reflect on their learning.

REMINDER: Collect learner worksheets to review and analyze learner's knowledge and understanding.

Science Grade 9 Lesson No. 6

History of Chemistry

Consolidation lesson

Component 1: Short Review (Time: 7 minutes)

- Ask learners to answer the following questions on their worksheets.

  Q1. Is Carbon a metal or a non-metal?

  Q2. If Aluminum has an electron configuration of 2,8,3, what would you predict its valency to be?

  Q3. If Oxygen is in period 2 of the periodic table how many electron shells does it have?

Ask learners to share their answers and offer positive feedback. Read out a sample answer (from a student or the provided examples) for everyone to listen to and take notes on.

Sample answers:

Q1. Carbon is a non-metal.

Q2. The valency of Aluminum is 3.

Q3. Oxygen has two electron shells.

Component 2: **Lesson Purpose** (Time: 3 minutes)

This lesson is about finding out that many of the elements and compounds that we have learned about are part of our daily lives.

The lesson may also help learners to better understand the chemistry of life.

Component 3: Lesson Language Practice (Time: 5 minutes)

- Read out difficult or unfamiliar words or phrases and ask the learners to read them to themselves and then out loud as a class, e.g.:

  Alchemy

- Ask the learners to practice saying the word.

- The definition for this word is in the stimulus text.

Component 4*:* Lesson Activity (Time: 25 minutes)

Component 4A

- Refer learners to the main lesson stimulus.
- Read out the written text. Ask the learners if there are any words that are not familiar with and give descriptions of any words that may be unfamiliar or confusing.

IMPORTANT HISTORY OF CHEMISTRY

The science teacher Mr. Mendoza believed that his learners in Grade 9 would be interested in the history of chemistry, so he put together the following article.

Looking at the past

A. *Alchemy*

Alchemists (ancient chemists) firstly in Greco-Roman Egypt, then in the Islamic world and then in Europe from the 12th to 16th centuries, regarded the elements of carbon, iron, sulfur, lead, silver, tin, gold, arsenic, bismuth, mercury, antimony, iron, and copper as pure substances. However, their dearest wish was to transform simple metals such as lead and copper into gold. They also wished to create an elixir that would allow people to live forever. They never achieved either of these wishes, but the study of the elements has provided the world with many useful materials.

B. Metals and alloys

The properties of metals, such as iron, have made it useful for many purposes, such as weapons and tools and it even had a historic era named from it – "the Iron Age". This was followed by the Bronze Age. Bronze is a metal alloy that is a mixture of the metals copper and tin. Bronze was made by the people in ancient Mesopotamia. It was used to make weapons, statues, coins, and bells.

Another important alloy is steel which is made from iron and carbon. Its more successful production in the 17th century made it a very important and useful product right up to the present times.

Carbon steel is still the most important metal alloy today because it is much harder than previous forms. Stainless steel is carbon steel with small amounts of chromium and or nickel.

C.* Organic *compounds

Some of the most important chemicals in our daily lives include the elements carbon, oxygen, nitrogen, and the compounds that contain them. Many of the compounds of carbon are related to living things and are called organic compounds. The study of these compounds is called Organic Chemistry. The most important compounds of oxygen include water, carbon dioxide and organic compounds. The other important element which is part of organic chemistry is nitrogen. An important compound of nitrogen is ammonia. Other important compounds of carbon that are not organic are calcium carbonate, carbon dioxide, sodium cyanide and silicon carbide.

Component 4B

- Read out the following questions and ask learners to answer in the space on their worksheet.

Q1. Name an important compound of Nitrogen that is not organic.

Q2. What is stainless steel made of?

Q3. What is bronze made from and what are its uses?

- Observe learners' answers. Ask the learners to share their answers. Give positive feedback. Select a good sample answer for all learners to write down. This may come from the learners or from the following sample answer.

Sample answers:

Q1. An important compound of nitrogen is ammonia. It is not organic.

Q2. Stainless steel is made of carbon steel plus chromium and or nickel.

Q3. Bronze is made of a mixture of copper and tin and is used to make weapons, coins, statues, and bells.

Component 4C

- Read the following questions and ask learners to answer in the space on their worksheet.

  Q1. An important metal in use today is aluminum. Why was it not used in ancient times?

  Q2. As there are 118 elements known today and chemistry is about these elements, what sort of careers/jobs do you think someone trained in chemistry could follow?

  Q3. **(Optional)** Why is water one of the most important compounds for living things?

- Observe learners' answers. Ask the learners to share their answers. Give positive feedback. Ask the learners to volunteer their answers, giving positive feedback. Select a good sample answer for all learners to write down. This may come from the learners or the following sample answer.

Sample answers:

Q1. Aluminum is found on Earth as ore bauxite and to obtain the metal from the ore is a difficult process not discovered in ancient times.

Q2. Someone trained in chemistry could follow a career path as a pharmacist, research chemist, as a biochemist, environmental chemist, forensic chemist, toxicologist, chemistry teacher, medical scientist, agricultural chemist, etc.

Q3. All animals and plants need water to survive. Water is the universal solvent it transports oxygen and nutrients around the body and takes away waste. The human body is more than ¾ water. Water makes our planet unique.

Component 5: Lesson Conclusion (Time: 5 minutes)

- The focus of this lesson was on elements and compounds in our daily lives.
- Ask learners to answer the following questions either by class discussion or by writing the answers in their worksheet.

  Q1. Has this lesson helped you to better understand the importance of chemistry? If so, how?

  Q2. What was hard to do or understand in the lesson?

Let learners know that good learners reflect on their learning.

REMINDER: Collect learner worksheets to review and analyze learner's knowledge and understanding.

Science Grade 9 Lesson No. 7

Cell Division

Key Idea

Mitosis and Meiosis are the basic forms of cell division and are critical to the reproduction and survival of all living things.

Component 1: Short Review (Time: 7 minutes)

- Ask learners to answer the following questions on their worksheet.

  Q1. Which process, mitosis, or meiosis, is involved in human reproduction?

  Q2. What do the processes of mitosis and meiosis have in common?

  Q3. What are the specialized organs for reproduction in humans?

Ask learners to share their answers and offer positive feedback. Read out a sample answer (from a student or the provided examples) for everyone to listen to and take notes on.

Sample answers:

Q1. Meiosis is involved in human reproduction.

Q2. They are both processes of cell division.

Q3. The specialized organs where meiosis occurs in humans are the testes and the ovaries.

Component 2: **Lesson Purpose** (Time: 5 minutes)

This lesson is about the processes of mitosis and meiosis and their importance for the reproduction of living things.

The lesson may also help learners to better understand the processes of biological inheritance.

Component 3: Lesson Language Practice (Time: 5 minutes)

- Read out difficult or unfamiliar words or phrases and ask the learners to read them to themselves and then out loud as a class, e.g.:

  meiosis; mitosis; chromosomes; gametes

- Ask the learners to practice saying the words.

  Meanings of possibly unfamiliar words.

- *A chromosome is formed from a long strand of a DNA molecule that contains a linear array of genes. Chromosomes also contain some proteins.*

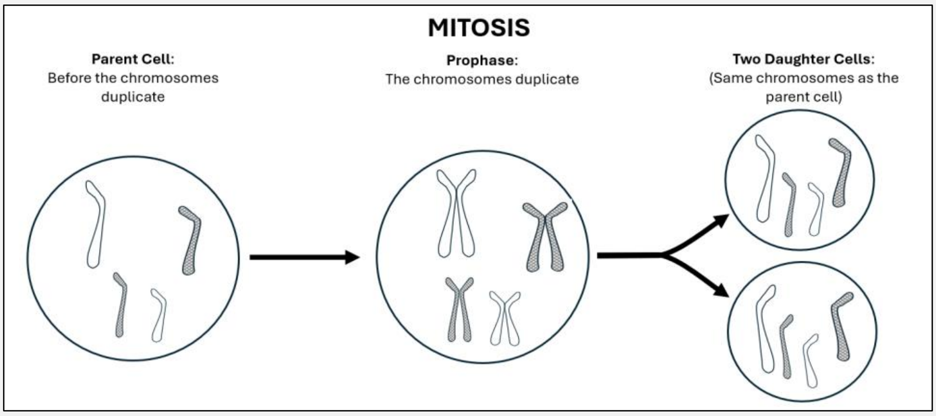
The other terms are defined in the stimulus.

Component 4*: Lesson Activity* (Time: 25 minutes)

Component 4A

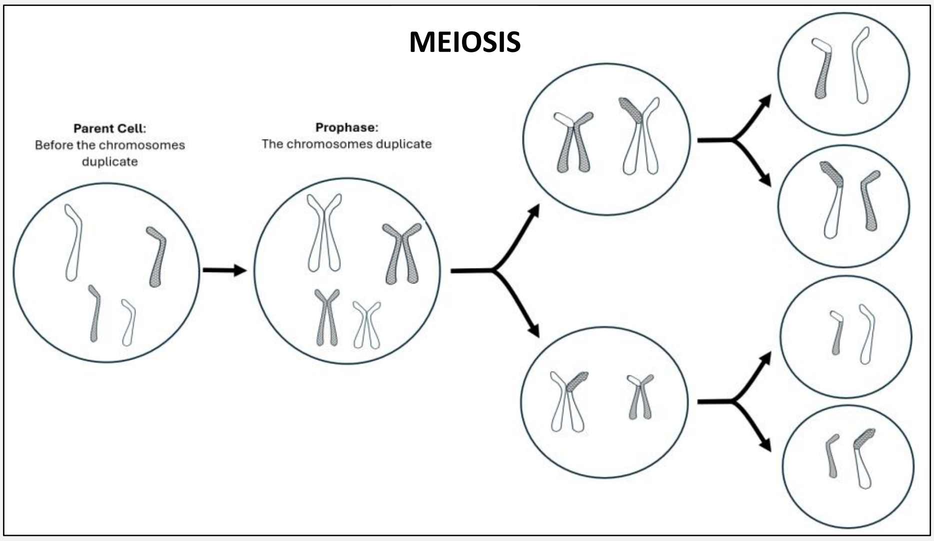
- Refer learners to the main lesson stimulus pointing out that it includes *diagrammatic representations of the processes of cell division* that help explain what is happening.

TWO TYPES OF CELL DIVISION



What is MITOSIS?
Mitosis is a process of cell division where two new cells are produced from one division of the original cell. Each of the two new daughter cells contains the same chromosome number and the same type and number of genes as the original parent cell.

Where does Mitosis happen? Our body cells increase in number through this process. All human body cells have forty-six chromosomes. When human cells reproduce through mitosis, each new cell will also have forty-six chromosomes.



What is MEIOSIS?
In meiosis, the cell goes through two processes of division. This produces four new daughter cells called **gametes.** These cells have only half the number of chromosomes as the parent cell (23). During fertilization, a male and female gamete unite resulting in the zygote, which has 46 chromosomes. In this complex process, some genes from each parent contribute and this explains the genetic variability of offspring.

Where does Meiosis happen? Meiosis occurs in the reproductive or sex cells, called sperms and eggs.

Component 4B

- Read the following questions and ask learners to answer in the space on their worksheet.

  Q1. How many daughter cells are produced in Mitosis?

  Q2. What number of cell divisions occur in Mitosis and Meiosis?

  Q3. How many cells are produced in Meiosis and how are they different to the cells produced in Mitosis?

- Observe learners' answers. Ask the learners to share their answers. Give positive feedback. Select a good sample answer for all learners to write down. This may come the learners or from the following sample answer.

Sample answers:

Q1. Mitosis produces two daughter cells.

Q2. In Mitosis there is one cell division but in Meiosis there are two cell divisions.

Q3. The key differences between meiosis and mitosis include the number of daughter cells produced (four haploid cells in meiosis compared to two diploid cells in mitosis) and the genetic diversity of the daughter cells (genetically unique haploid cells in meiosis compared to genetically identical diploid cells in mitosis). Additionally, meiosis involves two divisions, while mitosis involves only one division.

Component 4C

- Read the following questions and ask learners to answer in the space on their worksheet.

  Q1. What are the daughter cells produced through Meiosis called?

  Q2. What is the name given to the sex cells in humans?

  Q3. **(Optional)** Where does Mitosis occur in humans and why is it important?

- Observe learners' answers. Ask the learners to share their answers. Give positive feedback. Ask the learners to volunteer their answers, giving positive feedback. Select a good sample answer for all learners to write down. This may come from the learners or the following sample answer.

Sample answers:

Q1. They are called gametes.

Q2. They are called the sperm and the ova.

Q3. Mitosis occurs in the body cells in humans and is very important in producing more cells so that our bodies can grow and survive.

Component 5: Lesson Conclusion (Time: 5 minutes)

- The focus of this lesson was on the role of cell division in human reproduction.
- Ask learners to answer the following questions either by class discussion or writing the answers in their worksheet.

  Q1. Has this lesson helped you to better understand the processes of reproduction in cells? If so, how?

  Q2. Has this lesson helped you to remember the names of the processes? If so, how?

Let learners know that good learners reflect on their learning.

REMINDER: Collect learner worksheets to review and analyze learner's knowledge and understanding.

Science Grade 9 Lesson No. 8

Genes, DNA, and Chromosomes

Key Idea

DNA, and genes, and chromosomes carry important information in the process of biological inheritance.

Component 1: Short Review (Time: 7 minutes)

- Ask learners to answer the following questions on their worksheets.

  Q1. What is the process called that produces gametes?

  Q2. What process brings gametes together?

  Q3. Explain why some human cells have 46 chromosomes and some have only 23.

Ask learners to share their answers and offer positive feedback. Read out a sample answer (from a student or the provided examples) for everyone to listen to and take notes on.

Sample answers:

Q1. The process that forms gametes is called Meiosis.

Q2. The process that brings gametes together is called fertilization.

Q3. Most cells in the human body do have 46 chromosomes, however the gametes only have 23 which will pair up in fertilization to make 46 in the zygote.

Component 2: **Lesson Purpose** (Time: 3 minutes)

This lesson is about the important part that *chromosomes, DNA, and genes play in reproduction*.

The lesson may also help learners to better understand *inheritance.*

Component 3: Lesson Language Practice (Time: 5 minutes)

- Read out difficult or unfamiliar words or phrases and ask the learners to read them to themselves and then out loud as a class, e.g.:

heredity; genotype; genome; DNA; diploid; haploid

- Ask the learners to practice saying the words.

  Meanings of possibly unfamiliar words.

  - *Heredity means the passing on of physical or mental characteristics genetically from one generation to another.*
  - *A genotype is the genetic code.*
  - *The genome is the entire set of DNA of an organism.*
  - *Diploid means that the cell has two complete sets of chromosomes (one from each parent).*
  - *Haploid means the cell has a single set of chromosomes.*

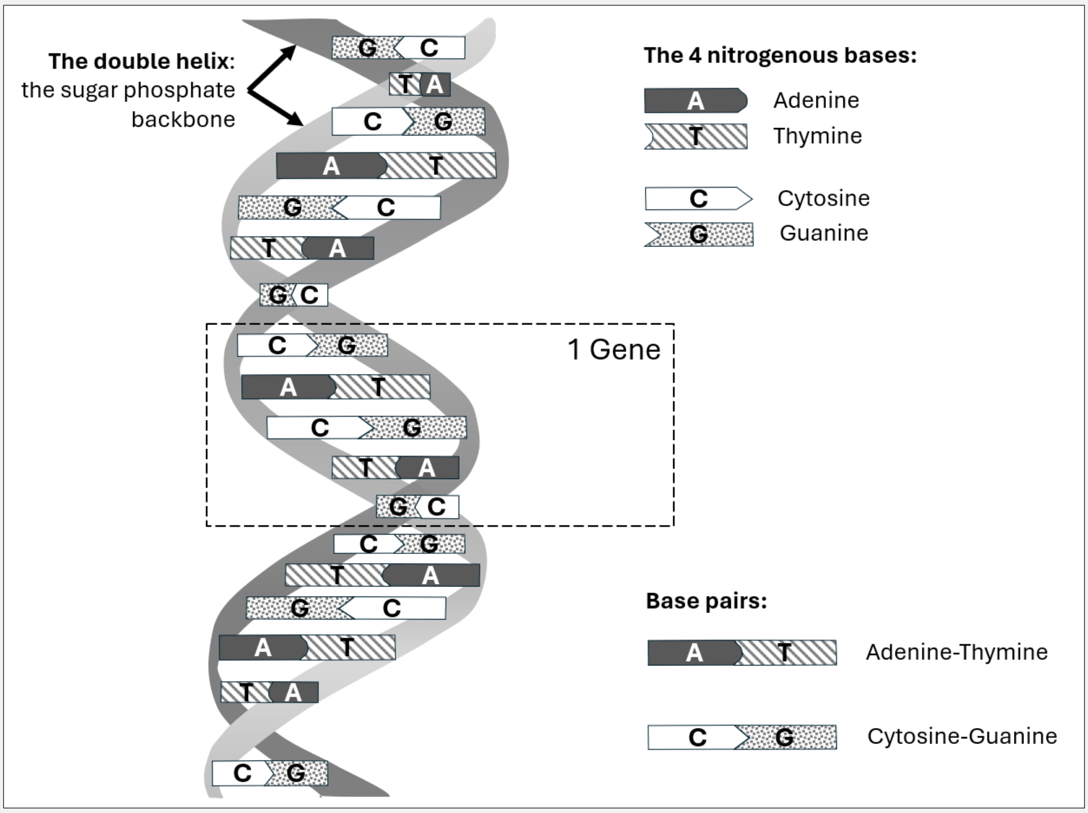
  The other terms are defined in the stimulus.

Component 4*: Lesson Activity* (Time: 25 minutes)

Component 4A

- Refer learners to the main lesson stimulus pointing out that it includes *diagrammatic representations of the DNA molecule.* Read out the written text. Ask the learners if there are any words that they are not familiar with and give descriptions of any words that may be problematic.

Genes, DNA, and Chromosomes



What is a gene? A gene is a segment of DNA and is the basic unit of heredity. We have two copies of each gene, one from our mother and one from our father. During fertilization, the gametes unite allowing genes from each parent to combine, which results in differences in the DNA composition or ***genotypes*** and therefore explains the genetic variability of offspring.

What is DNA? Deoxyribonucleic acid, or DNA, is the genetic material located inside a chromosome in the nucleus of the cell. All living things contain DNA, the self-replicating genetic material that directs the activities and functions of the cells. The DNA from the parents is transmitted to the offspring to ensure the continuity of life. It has a structure called a ***double helix***, which is very important during cell division.

What is a chromosome? Each chromosome is formed from a long strand of a DNA molecule that contains a linear array of genes. Chromosomes also contain some proteins.

How many chromosomes? The number of chromosomes in a cell is specific to the species. For example, fruit flies have 8 chromosomes while sunflowers have 34. Dogs have 78, humans have 46, rice has 24, and corn has 20. In humans, the chromosome number of the parent cell is ***diploid*** (***2n***), and the chromosome number of each of the four daughter cells is ***haploid*** (***n***).

What are mutations? **Where are they found**? A mutation is a change that occurs in our DNA sequence, either due to mistakes when the DNA is copied, or as the result of environmental factors such as UV light and cigarette smoke. Mutation occurs during DNA replication.

Component 4B

- Read out the following questions and ask learners to answer in the space on their worksheet.

  Q1. What is a gene?

  Q2. What is a genome?

  Q3. Of the three important features of human reproduction DNA, gene and chromosome, which is the largest and which is the smallest?

- Observe learners' answers. Ask the learners to share their answers. Giving positive feedback. Select a good sample answer for all learners to write down. This may come from the learners or from the following sample answer.

Sample answers:

Q1. A gene is a segment of DNA and the basic unit of heredity.

Q2. A genome is the entire set of DNA for an organism.

Q3. The largest of the three is the chromosome and the smallest is the gene.

Component 4C

- Read out the following questions and ask learners to answer in the space on their worksheet.

  Q1. What does DNA stand for?

  Q2. How does a mutation occur?

  Q3. **(Optional)** Explain the process of fertilization in terms of DNA?

- Observe learners' answers. Ask the learners to share. Give positive feedback. Ask the learners to volunteer their answers, giving positive feedback. Select a good sample answer for all learners to write down. This may come from the learners or from the following sample answer.

Sample answers:

Q1. DNA stands for Deoxyribonucleic acid.

Q2. A mutation occurs when there is a change in our DNA sequence either due to a mistake in replication or due to environmental factors.

Q3. The process of fertilization is when the sperm and the egg join to make a cell called the zygote. This allows the genes from each parent to combine and so results in differences in the DNA composition and therefore the differences in the offspring from the parents.

Component 5: Lesson Conclusion (Time: 5 minutes)

- The focus of this lesson was on the important processes of biological inheritance.

- Ask learners to answer the following questions either by class discussion or by writing the answers in their worksheet.

  Q1. Has this lesson helped you to better understand the importance of the DNA molecule? If so, how?

  Q2. What was hard to do or understand in the lesson?

Let learners know that good learners reflect on their learning.

REMINDER: Collect learner worksheets to review and analyze learner's knowledge and understanding.

Science Grade 9 Lesson No. 9

Body Systems Working Together

Key Idea

Body systems work together for the growth and survival of the organism.

Component 1: Short Review (Time: 7 minutes)

- Ask learners to answer the following questions on their worksheet.

  Q1. What do we/humans breathe in?

  Q2. What do we breathe out?

  Q3. Why do we need to breathe in and out?

- Ask learners to share their answers and offer positive feedback. Read out a sample answer (from a student or the provided examples) for everyone to listen to and take notes on.

Sample answers:

Q1. Humans breathe in air that has oxygen in it.

Q2. We breathe out air that has carbon dioxide in it.

Q3. The process of breathing in and out allows us to take in oxygen, which is necessary for cellular respiration and energy production, and remove carbon dioxide, a waste product of cellular metabolism. This exchange of gases ensures the proper functioning of our cells and overall survival

Component 2: **Lesson Purpose** (Time: 3 minutes)

This lesson is about how the respiratory and circulatory systems work together to keep us alive and healthy.

The lesson may also help learners to better understand that body systems work together and not as separate systems.

Component 3: Lesson Language Practice (Time: 5 minutes)

- Read out difficult or unfamiliar words or phrases and ask the learners to read them to themselves and then out loud as a class, e.g.:

  respiratory; circulatory; hemoglobin; alveoli; diffuses

- Ask the learners to practice saying the words.

  Meanings of possibly unfamiliar words.

  - Hemoglobin is a protein in red blood cells that carries oxygen.
  - Alveoli are tiny air sacs at the end of the bronchioles.
  - Diffuses means the natural movement of substances from an area of high concentration to an area of low concentration usually in and out of cells.

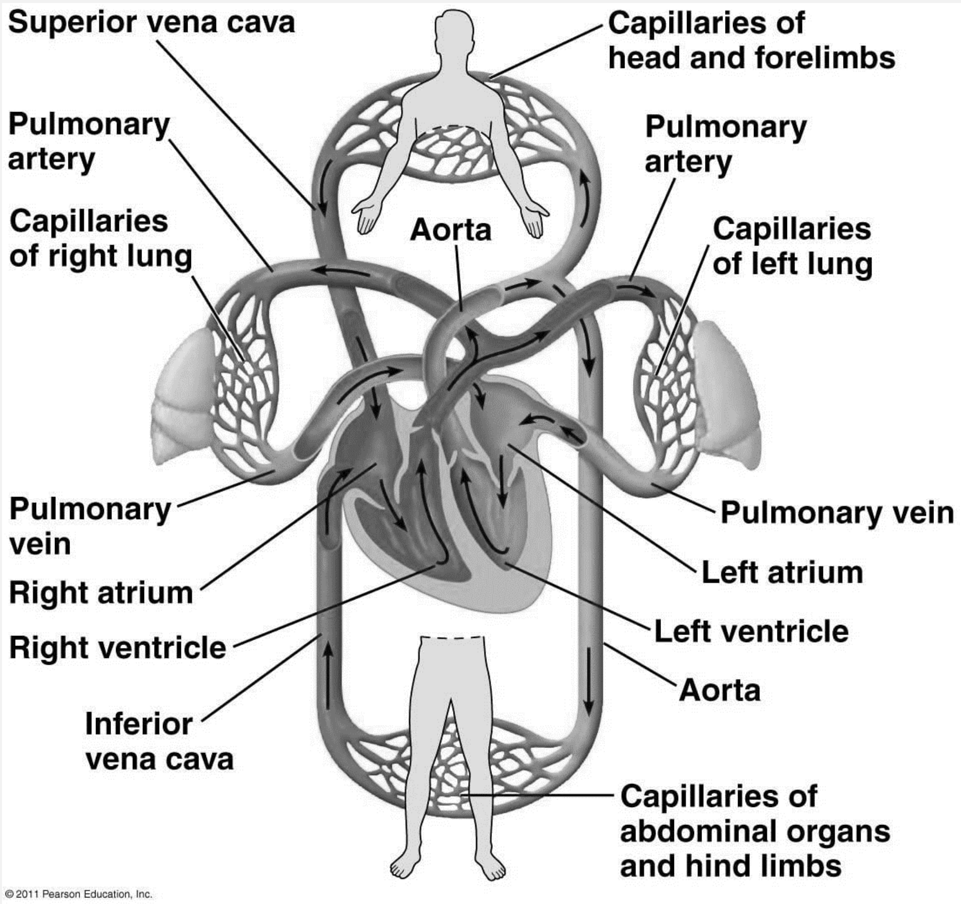
  The other terms are defined in the stimulus.

Component 4*:* Lesson Activity (Time: 25 minutes)

Component 4A

- Refer learners to the main lesson stimulus pointing out that it includes *diagrammatic representations of body systems* that help explain what is happening.
- Read out the written text. Ask the learners if there are any words that they are not familiar with and give descriptions of any words that may be problematic.

The Cardio-Respiratory System



Respiratory system: *Nose, Mouth, Trachea, Diaphragm, and Lungs (left and right) in which are found the Bronchi, Bronchioles, Capillaries, and Alveoli*.

Circulatory system: *Heart, Left ventricle, Right ventricle, Left atrium, Right atrium, Blood vessels such as veins (e.g. Pulmonary vein, Inferior vena cave, Superior vena cave), and arteries (e.g. Aorta, Pulmonary artery).* This system is also important in transporting nutrients from the *digestive system* to the cells of the body and moving waste products from the cells to the *kidney*.

Gas Exchange: Oxygen diffuses into the *alveoli* and bonds to hemoglobin in the blood and the carbon dioxide from the blood diffuses into the *alveoli* and out again through the respiratory system.

Component 4B

- Read out the following questions and ask learners to answer in the space on their worksheet.

  Q1. The diaphragm is part of the respiratory system. What is its job?

  Q2. The pulmonary vein is part of the circulatory system. What is its job?

  Q3. The aorta is the largest artery in our body. What is its job?

- Observe learners' answers. Ask the learners to share their answers. Give positive feedback. Select a good sample answer for all learners to write down. This may come from the learners or the following sample answer.

Sample answers:

Q1. The diaphragm is a band of muscle, and its job is to help the ribs move in and out so that we can breathe.

Q2. The pulmonary vein carries oxygenated blood from the lungs to the left atrium/heart.

Q3. The job of the aorta is to carry oxygenated blood from the left ventricle/heart to all the parts of the body including the head, arms, and legs etc.

Component 4C

- Read out the following questions and ask learners to answer in the space on their worksheet.

  Q1. What is the name of the blood vessel that carries deoxygenated blood back to the heart?

  Q2. What are the alveoli and where are they located?

  Q3. **(Optional)** Explain the important role of the alveoli in the cardio-respiratory system.

- Observe learners' answers. Ask the learners to share their answers. Give positive feedback. Ask the learners to volunteer their answers, giving positive feedback. Select a good sample answer for all learners to write down. This may come from the learners or the following sample answer.

Sample answers:

Q1. The vena cava carries deoxygenated blood back to the heart.

Q2. The alveoli are tiny sacs surrounded by capillaries located at the end of the bronchioles in the lungs.

Q3. Oxygen diffuses through the thin walls of the alveoli into the capillaries. The oxygen bonds with a substance called hemoglobin which is carried in the red blood cells. The carbon dioxide in the plasma/blood diffuses into the walls of the alveoli.

Component 5: Lesson Conclusion (Time: 5 minutes)

- The focus of this lesson was on *how the two important body systems, respiratory and circulatory, work together to keep us alive and healthy.*
- Ask learners to answer the following questions either by class discussion or writing the answers in their worksheet.

  Q1. Has this lesson helped you to better understand how our body works? If so, how?

  Q2. Has this lesson helped you to remember the names of important body parts? If so, how?

REMINDER: Collect learner worksheets to review and analyze learner's knowledge and understanding.

Science Grade 9 Lesson No. 10

What is Needed for a Volcano to Form?

Key Idea

Volcanoes form over time through a combination of geological processes and conditions including having a source of magma and some weakness in the Earth's crust for the magma to come to the surface.

Component 1: Short Review (Time: 7 minutes)

- Ask learners to answer the following questions on their worksheet.

  Q1. What is a volcano?

  Q2. What materials are ejected by volcanoes?

  Q3. How does a volcano form?

Ask learners to share their answers and offer positive feedback. Read out a sample answer (from a student or the provided examples) for everyone to listen to and take notes on.

Sample answers:

Q1. A cone-shaped (round) hill or mountain with a crater at the top [where molten rock (lava) and gases comes out of the Earth]

Q2.
- *molten rock (lava)*
- *gases;* or *steam /vapor*
- *smoke,*
- *ash,* or *ash clouds,*
- *rock fragments*
- *pyroclastic flows,*
- *volcanic bombs*
- *etc.*

Q3. Volcanoes are complex geological features that result from the dynamic processes occurring beneath the Earth's surface, driven primarily by the movement and interactions of tectonic plates

Component 2: **Lesson Purpose** (Time: 3 minutes)

This lesson is about the key factors that are needed for a volcano to form.

The lesson aims to help learners better identify and extract information from a scientific text that uses a lot of technical scientific language. The emphasis is to support learners to understand the structure of the text, and the style of language used, in order to be more efficient at finding answers to the questions asked.

Component 3: Lesson Language Practice (Time: 5 minutes)

- Read out difficult or unfamiliar terms and ask the learners to read them to themselves and then out loud as a class, e.g.:

  factor; geological processes and conditions; magma; runny lava; viscous lava

- Ask the learners to practice saying the words. Talk out meanings – e.g. A ***factor*** is *something that contributes/a part*. ***Processes*** are *actions that lead to a result*. ***Conditions*** are the *things or factors that are occurring at a particular time*.
- Terms like *magma* and *lava* may have unique mother tongue meanings in some regions.

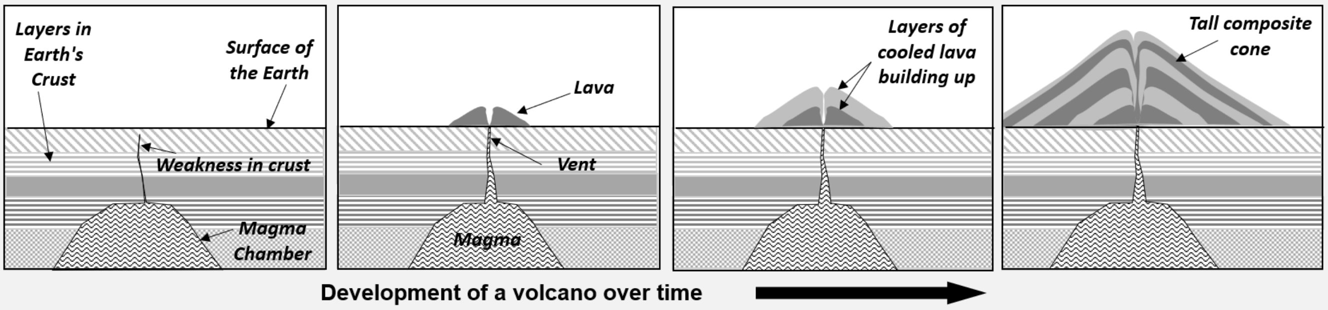
Component 4*:* Lesson Activity (Time: 25 minutes)

Component 4A

- Refer learners to the main lesson stimulus which describes the general factors that affect how volcanoes form. The stimulus includes a 'comic strip' style diagram to help show stages in volcano development. There may be value in helping learners to understand how the text is organized: 1. an overview paragraph; 2. the diagram; 3. seven key factors (each with more details). Understanding how the text is organized will help learners to ***locate information*** to answer the questions.

HOW DO VOLCANOES FORM?

Volcanoes don't just pop up anywhere on the Earth. They develop where there are certain conditions in and under the Earth's crust. They form through a combination of geological processes and conditions.



The following factors, that are needed for a volcano to form, affect its size and shape:

Magma source: *Magma* is molten rock that forms from the partial melting of the Earth's mantle or crust. *Magma chambers* beneath the surface are needed to provide the initial material for volcanic activity.

Rising Magma: Once formed, magma rises towards the Earth's surface due to buoyancy forces. Rising magma is driven by the pressure difference between the magma chamber and the surface, as well as the density difference between the magma and the surrounding rocks.

Weakness in Earth's crust: Volcanoes often form at locations where there are weaknesses in the Earth's crust, such as *faults* or *fractures* in rocks, or along *tectonic plate boundaries*, or *rift zones*. These weak points provide pathways for magma to reach the surface, leading to volcanic eruptions.

Conduit or vent: As magma rises towards the surface, it may create *conduits* or *vents* through which it can erupt. These conduits serve as channels for the movement of magma and volcanic gases from the magma chamber to the surface. The shape and size of a conduit can influence the type and intensity of volcanic eruptions.

Type of eruption: When magma reaches the Earth's surface it is called *lava*. Lava may erupt gently or explosively, depending on factors such as the *composition* of the source magma, the *gas content*, and the *eruption style*. Gentle or effusive eruptions involve runny lava and low gas. They have a relatively calm outpouring of lava onto the surface, forming *lava flows* and *lava domes.* Explosive eruptions involve thick or viscous lavas with rapid release of *volcanic gases* and *shattered magma*, leading to the formation of *ash clouds*, *pyroclastic flows*, and *volcanic bombs*.

Build-up of volcanic material: Over time, repeated volcanic eruptions can result in the accumulation of volcanic materials, such as *lava flows*, *ash deposits*, and *volcanic rocks*, around the vent. These materials contribute to the growth and shape of the volcano, forming characteristic features such as *cones*, *craters*, and *calderas*.

Geological time: Volcanoes form over geological time scales, through a series of volcanic eruptions and volcanic processes. The growth and evolution of a volcano may span thousands to millions of years, depending on factors such as *magma supply*, *eruption frequency*, and *tectonic activity*.

Component 4B

- Read the following questions and ask learners to answer in the space on their worksheet.

  Q1. What is *magma*?

  Q2. List the factors that are needed for a volcano to form?

  Q3. The following list of sentences gives the events that occur when a large volcano form.
  They are NOT presented in the correct ORDER or SEQUENCE. Rewrite or show where the sentences fit into the flow chart to show the CORRECT order of events that occurs to form a big volcano. The first one has been done for you.

Molten lava erupts out of the vent onto the Earth's surface.
More eruptions of lava and ash come from the vent and cool to build the volcano.
Magma forces into a weakness in the crust to form a vent.
A hot magma source develops in the Earth's crust.
Molten lava cools on the Earth's surface to form a small hill or mount.

Flowchart showing the sequence of events when a large volcano forms:

A hot magma source develops in the Earth's crust.
↓
↓
↓
↓

- Observe learners' answers. Ask the learners to share their answers. Give positive feedback. Select a good sample answer for all learners to write down. This may come from the learners or from the following sample answer.

Sample answers:

Q1. Magma is molten rock that forms from the partial melting of the Earth's mantle or crust.

Q2. Several factors contribute to the formation of a volcano:

Magma Source: A volcano forms when molten rock, known as magma, rises from the Earth's mantle to the surface. The magma can originate from various sources, including mantle plumes, subduction zones, and divergent boundaries.

Weakness in Earth's Crust: Volcanoes often form at locations where there are weaknesses or fractures in the Earth's crust, such as tectonic plate boundaries or hot spots. These weaknesses provide pathways for magma to reach the surface.

Magma Ascent: For a volcano to form, magma must be able to ascend from its source in the mantle to the Earth's surface. This ascent is facilitated by factors such as buoyancy (magma is less dense than surrounding rock), pressure differences, and the presence of fractures or conduits in the crust.

Temperature and Pressure Conditions: The temperature and pressure conditions within the Earth's crust and mantle influence the viscosity (thickness) of the magma and its ability to flow. Magma with lower viscosity is more likely to erupt explosively, while magma with higher viscosity tends to produce more effusive eruptions.

Water Content: The presence of water and other volatiles (gases) in magma can significantly affect volcanic activity. Water lowers the melting point of rocks, making it easier for magma to form, and can also increase magma viscosity. Additionally, the release of gases during volcanic eruptions can drive explosive eruptions.

Time: Volcanic eruptions often occur over long periods of time, as magma slowly accumulates beneath the Earth's surface and pressure builds up. The formation of a volcano is therefore a gradual process that can span thousands to millions of years.

Geological Setting: The geological setting, including the type of tectonic plate boundary or volcanic hotspot, influences the type and behavior of volcanic activity. For example, convergent plate boundaries are associated with explosive stratovolcanoes, while divergent plate boundaries are associated with effusive shield

Q3. Sample completed flowchart:

A hot magma source develops in the Earth's crust.

↓

Magma forces into a weakness in the crust to form a vent.

↓

Molten lava erupts out of the vent onto the Earth's surface.

↓

Molten lava cools on the Earth's surface to form a small hill or mount.

↓

More eruptions of lava and ash come from the vent and cool to build the volcano.

Component 4C

- Read the following questions and ask learners to answer in the space on their worksheet.

  Q1. Name a type of volcanic eruption identified in the stimulus text?

  Q2. What are the things that affect the type of eruption that a volcano has?

  Q3. **(Optional)** How does the composition of magma affect the shape of a volcano?

- Observe learners' answers. Ask the learners to volunteer their answers, giving positive feedback. Ask the learners to volunteer their answers, giving positive feedback. Select a good sample answer for all learners to write down. This may come from the learners or the following sample answer.

Sample answers:

Q1.
- *Gentle, or Effusive;*
- *Explosive*

Q2. • *The composition of the source magma;* or *the composition of the lava;*
- *Runny lava produces relatively quiet or gentle eruptions;*
- *Thick or viscous lava produces more explosive eruptions;*
- *The gas content - quiet eruptions have low gas; explosive eruptions have high gas content*

Q3. If a volcano comes from thick or viscous magma, its lava will not run far and so will build up high around the vent forming a tall cone-shaped volcano.

Component 5: Lesson Conclusion (Time: 5 minutes)

1. What did you learn from this lesson?
2. What are some things you enjoyed about the lesson?
3. What is something you would like to learn more about in this topic?

REMINDER: Collect learner worksheets to review and analyze learner's knowledge and understanding.

Science Grade 9 Lesson No. 11

Types of Volcanoes

Key Idea

The different types of volcanoes found around the world are classified according to their activity and the types of materials they erupt.

Component 1: Short Review (Time: 7 minutes)

- Ask learners to answer the following questions on their worksheet.

  Q1. What is the name of a volcano you know about?

  Q2. What features does it have?

  Q3. Why do you think it has those features?

- Ask learners to share answers. Give positive feedback. The intention is that learners identify and describe real volcanoes.

Sample answers:

Q1. Learners can name any volcano that they know whether it is in the Philippines or somewhere else in the World. Here are some possible answers:

. • Philippines examples*: Babuyan Claro, Banahaw, Biliran, Bulusan, Cabalian, Cagua, Hibok-Hibok, Iriga, Isarog, Kanlaon, Leonard Kniaseff, Makaturing, Matutum, Mayon, Mélébingóy, Musuan, Parker Pinatubo, Ragang, Taal.*
- Other famous volcanoes in the World: *Mount Vesuvius (Italy), Krakatoa (Indonesia), Mount St Helens (USA), Eyjafjallajökull (Iceland), Mount Fuji (Japan), Popocatépetl (Mexico), Mauna Loa (Hawaii), Mount Tambora (Indonesia), Mount Pelée (Martinique).*

Q2. Learners might suggest such things as:
- *size, height; profile (steep or low angled),*
- *activity (quiet, explosive, smoldering, active/dormant/inactive);*
- *composition – lava/ash; etc.*

Q3. Learners might suggest such things as:
- *It is steep because it has built up over millions of years.*
- *it is smoldering because it is active.*
- *it is dormant because it has not erupted for a long time*
- *it is small because it only erupts steam and ash which gets washed away.*

Component 2: **Lesson Purpose** (Time: 3 minutes)

This lesson is about some different types of volcanoes and why they have their characteristic features. The lesson should help learners to better appreciate the sizes of volcanoes, especially how big and small they can be. The key point is for learners to understand that the size and shape of volcanoes are closely related to their activity and the types of materials they erupt.

Component 3: Lesson Language Practice (Time: 5 minutes)

- Read out difficult or unfamiliar words or phrases and ask the learners to read them to themselves and then out loud as a class, e.g.:

  Shield* volcano*; Strato-volcano; Caldera; Cinder cone

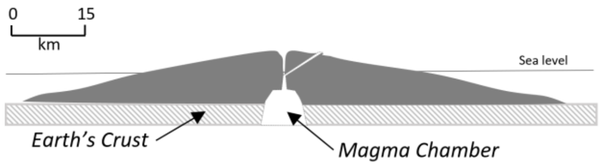
- Ask the learners to practice saying the words. Ask the learners to say why they think volcanoes have these names. [they are about either their shapes or what they are made of; e.g. *Caldera* comes from the Spanish name for a cooking pot or *Caldron*].

- NOTE: The term phreatic originates from the Greek *phrear*, meaning a water "well" or "spring".

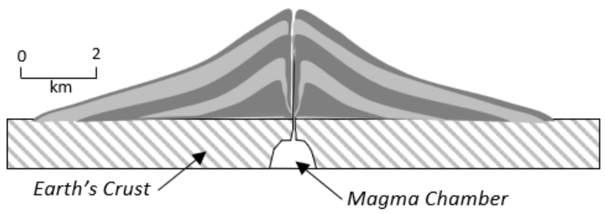
Component 4A

- Refer learners to the main lesson stimulus about some different types of volcanoes. Point out the written text supports the cross-sectional diagrams to reinforce the sizes and shapes of the volcanoes. Point out that technical science terms are often in *italic writing*.

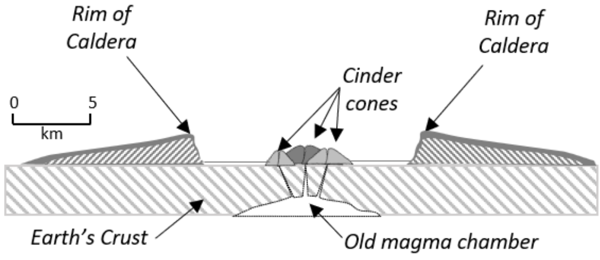
THREE TYPES OF VOLCANOES



SHIELD VOLCANOES: These are the largest types of volcanoes. They are made up of many layers of runny *basaltic* lava, which has fast-flowing lava that spreads far, building a large mountain with a shallow slope (the volcano slope angle averages about 12^o). The biggest in the world is Mauna Loa in Hawaii, USA, which rises about 10km off the ocean floor to from an island in the Pacific Ocean. It is about 100km across. Shield volcanoes often have more than one vent and they usually have continuous, relatively quiet, eruptive activity over extremely long periods of time.



STRATO-VOLCANOES: These are tall volcanoes, made up of alternating layers of *viscous* lava and ash that pile up to form a tall symmetrical cone. The lava often alternates from *andesite* to *rhyolite* lava types and so the lava is usually thicker and does not flow very quickly – this results in the volcano slope being about $35\text{-}40^o$. Strato-volcanoes can have both explosive steam-blast eruptions with ash as well as lava flows and this provides their characteristic layering. Mayon volcano in the Philippines has a classic symmetrical cone shape. Its base is about 13km across, with a circumference of over 100km. Mayon rises 2,462m from the shores of Albay Gulf. At the summit it has a crater that is 250m wide. Recently, it has had big eruptions about every 3-5 years.



CALDERA with CINDER CONES:
Calderas are large, bowl-shaped volcanic depressions formed by the collapse of the ground surface following a volcanic eruption when the magma chamber beneath a volcano is emptied. Calderas often have new volcanic activity after the initial collapse, resulting in the uplift of the caldera floor where new smaller volcanoes might form.
Taal Volcano near Manilla is only about 300m high and has four or five vents in the center of a big caldera. It is known for *phreatic and phreatomagmatic* eruptions because of the presence of Taal Lake within its caldera. When magma comes into contact with water from the lake or groundwater, it can lead to highly explosive eruptions with ash plumes and pyroclastic flows. This can include ash, lapilli (small rock fragments) and volcanic bombs (larger ejected rocks).

Component 4B

- Read out the following questions and ask learners to answer in the space on their worksheet.

  Q1. Which type of volcano is the biggest to form on Earth?

  Q2. What physical features do *strato-volcanoes* have?

  Q3. Why do *strato-volcanoes* have steeper sides than *shield volcanoes*?

- Observe learners' answers. Ask the learners to share their answers. Give positive feedback. Select a good sample answer for all learners to write down. This may come from the learners or from the following sample answer.

Sample answers:

Q1. Shield volcanoes

Q2.
- *They are made up of alternating layers of lava and ash.*
- *Their lava often alternates from andesite to rhyolite lava types*
- *Their lava is usually thick and does not flow very quickly*
- *Their slopes are angled at about 35^{o}-40^{o}*
- *They have tall symmetrical cones.*
- *They have viscous (thick) lava.*
- *They can have explosive steam-blast eruptions with ash erupted*
- *They can have lava flows as well as ash*
- *Their craters can be around 250m wide*

Q3. Strato volcanoes have thicker lava than shield volcanoes which do not flow very quickly so the volcano builds very steep sides.

Component 4C

- Read the following questions and ask learners to answer in the space on their worksheet.

  Q1. What is a phreatic eruption?

  Q2. What types of materials do volcanoes in the Philippines mostly erupt?

  Q3. **(Optional)** What might be the stages that occur over time to produce a caldera system like the Taal Caldera?

- Observe learners' answers. Ask the learners to share their answers. Givie positive feedback. Ask the learners to volunteer their answers, giving positive feedback. Select a good sample answer for all learners to write down. This may come from the learners or the following sample answer.

Sample answers:

Q1. A phreatic eruption, also known as a steam-driven eruption or phreatic explosion, occurs when groundwater or surface water is heated by magma or hot volcanic rocks, causing it to flash to steam and generate a sudden and explosive release of pressure. Unlike other types of volcanic eruptions that involve the ejection of magma, phreatic eruptions primarily involve the ejection of steam, water, ash, and other volcanic gases.

Q2.
- *ash plumes*
- *pyroclastic flows with lapilli (small rock fragments) and volcanic bombs (larger ejected rocks).*
- *viscous lava*
- *andesite to rhyolite lava types*
- *steam-blasts.*
- Learners may include more from their knowledge or experiences with local volcanoes e.g.*: volcanic mudflows (lahars); hot volcanic gases including sulfur dioxide (SO_2), carbon dioxide (CO_2), hydrogen sulfide (H_2S), and water vapor.*

Q3. • [A short answer] ***Stages***: ***1.*** *A big volcano forms;* ***2.*** *The magma chamber empties;* ***3***. *A bowl-shaped depression forms by ground collapse;* ***4***. *The depression fills with water to create a large lake;* ***5***. *New volcanic activity results in an uplift of the lake floor;* ***6***. *New volcanic activity occurs in the center of the caldera lake.*

- [A possible detailed answer] ***Stages***: ***1.*** *A big volcano initially forms (such as a strato-volcano);* ***2.*** *The magma chamber beneath the volcano empties;* ***3***. *A. large, bowl-shaped volcanic depression forms by the collapse of the ground surface following the last big volcanic eruption;* ***4***. *The large, bowl-shaped volcanic depression may fill with water to create a large volcanic lake;* ***5***. *New volcanic activity may occur after the initial collapse, resulting in the uplift of the caldera floor where new smaller volcanoes might form;* ***6***. *The new volcanic activity may involve phreatic and phreatomagmatic eruptions; many smaller volcanoes and small cinder cones forming in the center of the caldera lake.*

Component 5: Lesson Conclusion (Time: 5 minutes)

- The focus of this lesson was on classifying volcanoes according to their activity and the types of materials they erupt.
- Ask learners to answer the following questions either by class discussion or by writing the answers in their worksheet.

Q1. Has this lesson helped you to better understand the types of volcanoes? If so, how?

Q2. Has this lesson helped you to remember the difference between a strato-volcano and a shield volcano? If so, how?

Q3. What was hard to do or understand in the lesson?

REMINDER: Collect learner worksheets to review and analyze learner’s knowledge and understanding.

Science Grade 9 Lesson No. 12

TAAL – A Very Small But Dangerous Volcano!

CONSOLIDATION LESSON

Component 1: Short Review (Time: 7 minutes)

- Ask learners to answer the following questions on their worksheet.

  Q1. Where is Taal Volcano located?

  Q2. What are the indicators that a volcano might erupt?

  Q3. Why are volcanoes dangerous?

Ask learners to share their answers and offer positive feedback. Read out a sample answer (from a student or the provided examples) for everyone to listen to and take notes on.

Sample answers:

Q1. In southern Luzon about 50km south of Manila.

Q2.
- *An increase in earthquake activity*
- *Steam coming from the volcano vent*
- *Enlarged areas of hot ground*
- *Ground swelling:*

Q3.
- *Hot or poisonous gases being released that will kill people and livestock.* or
- *An eruption of ash settles on the nearby crops and people.* or
- *Ejection of hot rocks or rock fragments (volcanic bombs) that might hit people and buildings,* or
- *Eruption of hot lava that might engulf and bury towns and people.*

[Good answers are ***relational*** – they show how a volcano might be dangerous to living things and infrastructure.]

Component 2: **Lesson Purpose** (Time: 3 minutes)

This lesson is a consolidation lesson. It is designed to give opportunities to use your knowledge and understanding of volcanoes to answer questions related to authentic scientific reports of volcanoes and eruptions.

Component 3: Lesson Language Practice (Time: 5 minutes)

- Read out difficult or unfamiliar words or phrases and ask the learners to read them to themselves and then out loud as a class, e.g.:

  caldera system; phreatic eruption; phreatomagmatic eruption

- Ask the learners to practice saying the words.

- In the last lesson, learners found out about a ***phreatic eruption.*** Ask the learners to try and work out what a '***phreatomagmatic eruption'*** is. [An eruption caused by the interaction of both magma and water]

Component 4*:* Lesson Activity (Time: 25 minutes)

Component 4A

- Point out that the main lesson stimulus is an authentic scientific report about a recent eruption of Taal Volcano. Paragraphs are numbered to help teachers to direct learners to parts of the report.

Taal, Philippines

14.0106°N, 120.9975°E; Summit elev. 311 m

All times are local (unless otherwise noted)

Taal volcano is in a caldera system located in southern Luzon and is one of the most active volcanoes in the Philippines. Around 35 eruptions have been recorded since 3,580 BC. The caldera contains a lake with an island that also contains a lake within the Main Crater. Before 2020, the most recent eruption was in 1977. The United Nations office, in the Philippines, reports over 450,000 people live within 40 km of the caldera. [Para 1]

This report covers activity during January through February 2020, including the 12 to 22 January eruption and is based on reports by the *Philippine Institute of Volcanology and Seismology* (PHIVOLCS), satellite data, geophysical data, and media reports. [Para 2]

Classification information: PHIVOLCS classifies Taal Volcano's eruptions into four categories – ***phreatic*** (water-driven), ***phreatomagmatic*** (interaction of both magma and water), ***Strombolian*** (lava fountaining and lava flow), and ***Plinian*** (violent explosive eruption with tall eruption columns and widespread fallout of tephra or rock fragments).

The hazard status at Taal was raised to Alert Level 1 on 28 March 2019. From that date through to 1 December there were 4,857 earthquakes registered, with some felt nearby. Inflation was detected during 21-29 November and an increase in CO_2 emission within the Main Crater was observed. Seismicity increased beginning at 11:00 on 12 January. At 13:00 there were phreatic (steam) explosions from several points inside the Main Crater and the Alert Level was raised to 2 (increasing unrest). Booming sounds were heard in Talisay, Batangas, at 14:00; by 14:02 the plume had reached 1 km above the crater, after which the Alert Level was raised to 3 (magmatic unrest). A seismic swarm began at 11:00 on 12 January. [Para 3]

This was followed by a ***phreatic eruption*** at 13:00. The initial activity consisted of steaming from at least five vents in the Main Crater and phreatic explosions that generated 100-m-high plumes. PHIVOLCS raised the Alert Level to 2. Booming sounds were heard at 14:00 in Talisay, Batangas (4 km NNE from the Main Crater), and at 14:04 volcanic tremor and earthquakes felt locally were accompanied by an eruption plume that rose 1 km; ash fell to the SSW. The Alert Level was raised to 3 and the evacuation of high-risk Barangays was recommended. [Para 4]

Activity again intensified around 17:30, prompting PHIVOLCS to raise the Alert Level to 4 and recommend a total evacuation of the island and high-risk areas within a 14-km radius. The eruption plume of steam, gas, and tephra significantly intensified, rising to 10-15 km altitude and producing frequent lightning. Wet ash fell as far away as Quezon City (75 km N). According to news articles, schools and government offices were ordered to close and the Ninoy Aquino International Airport (56 km N) in Manila suspended flights. About 6,000 people had been evacuated. Residents described heavy ashfall, low visibility, and fallen trees. [Para 5]

Report reference: Global Volcanism Program, 2020. Report on Taal (Philippines) (Krippner, J.B., and Venzke, E., eds.). *Bulletin of the Global Volcanism Network*, 45:6. Smithsonian Institution. https://doi.org/10.5479/si.GVP.BGVN202006-273070

Component 4B

- Read the following questions and ask learners to answer in the space on their worksheet.

  Q1. What is a ***phreatic eruption?***

  Q2. Before the eruption (at 13:00 on 12 January), what signs were noticed before the eruption?

  Q3. What was the sequence of occurrences once the eruption had begun?

- Observe learners' answers. Ask the learners to share their answers. Give positive feedback. Select a good sample answer for all learners to write down. This may come from the learners or from the following sample answer.

Sample answers:

Q1. A water-driven eruption, or *Steam explosion.*

Q2. [See paragraph 3]:

- *Many (4,857) earthquakes registered, some felt nearby.*
- *Inflation (ground swelling and rising).*
- *An increase in Carbon dioxide (CO_2) emission within the Main Crater*
- *Increased seismicity (earthquake activity).*
- *A seismic swarm began just before the eruption.*

Q3. **A good, simple answer:**

***Phreatic (steam) explosions** → **Booming sounds** → **Steam plume** to 1 km high → A **seismic swarm** → **A phreatic eruption,** steaming → **phreatic explosions** to 100m high → **Booming sounds** heard 4 km away → **Volcanic tremor and earthquakes** felt locally → **An eruption plume** rising 1 km; **ash fall** → **Activity again intensified - eruption plume of steam, gas, and tephra** and **frequent lightning** → **Wet ash** falling at Quezon City (75 km N).*

A good, detailed answer [drawn from paragraphs 4 and 5].:

1. *At 13:00 - **phreatic (steam) explosions** from several points inside Main Crater*
2. *At 14:00 - **booming sounds** were heard in Talisay, Batangas,*
3. *By 14:02 - the **plume reached 1 km above the crater***
4. *At 11:00 - a **seismic swarm began***
5. *At 13:00 - **a phreatic eruption** consisting of steaming from at least five vents in Main Crater and **phreatic explosions** that generated 100-m-high plumes.*
6. *At 14:00 - **booming sounds** were heard in Talisay, Batangas (4 km NNE from the Main Crater),*
7. *At 14:04 - **volcanic tremors and earthquakes felt locally**, accompanied by **an eruption plume that rose 1 km**; **ash fell** to the SSW.*
8. *Around 17:30 - **activity again intensified**, with the **eruption plume of steam, gas, and tephra** significantly intensifying, rising to 10-15 km altitude, and producing **frequent lightning**. **Wet ash fell as far away as Quezon City (75 km N).***

Component 4C

- Read the following questions and ask learners to answer in the space on their worksheet.

  Q1. What is a Caldera System?

  Q2. What are the physical features of the Taal Caldera?

  Q3. **(Optional)** Develop a table that compares the key features of Taal Volcano to either Mayon Volcano, or Mount Pinatubo.

- Observe learners' answers. Ask the learners to volunteer their answers, giving positive feedback. Ask the learners to volunteer their answers, giving positive feedback. Select a good sample answer for all learners to write down. This may come from the learners or the following sample answer.

Sample answers:

Q1. A caldera system contains small volcanoes (often with small craters) within a bigger older volcanic crater.

Q2.
- *It is a big caldera containing a lake with an island that also contains a lake within the main crater.*
- *It has a central crater that has a summit elevation of 311 m.*
- *The main crater has at least five vents*

Q3. A sample table. Sample features for both comparison volcanoes provided for teacher information:

Features	***Taal***	***Mayon***	***Mount Pinatubo***
Location	Batangas Province Luzon, Philippines	Albay Province, Luzon, Philippines	Zambales Province, Luzon, Philippines
Type of volcano	Complex caldera volcano	Stratovolcano	Stratovolcano
Height	311 meters	2,462 meters	600 meters
Size	25 kilometers across	*130 km across*	2.5 kilometers across
Eruptions/ Activity	Low to moderately explosive	Moderately explosive	Very explosive
Erupted material	Mostly steam and ash with some tephra or rock fragments and lava fountains.	Pyroclastic flows, ash and andesitic lava	Ash and andesitic lava

Reference: Phivolcs explains science behind Taal Volcano eruption (mb.com.ph)

Component 5: Lesson Conclusion (Time: 5 minutes)

The focus of the lesson was on consolidating knowledge and understanding about Philippine volcanoes.

1. Could you find any answers in the Stimulus text provided for questions in Component **4B** or **4C**? Which ones?

   Learners can find direct answers to 4B Q1, Q2 and Q3 and 4C Q1 and Q2.

> e.g., It can be helpful to explain to learners that it is good learning technique to look for answers that might be given in a text or stimulus. This also helps understanding what is needed to answer questions.

2. What connections or differences do you notice between questions in **4B** and **4C.**
3. Did you find it easier to answer the questions in Component **4B** or **4C**? Why?

REMINDER: Collect learner worksheets to review and analyze learner's knowledge and understanding.

Science Grade 9 Lesson No. 13

Temperature and Heat – What is the Difference?

Key Idea

Temperature is a measure of the average kinetic energy of particles in an object or system. This is not the same as *heat*, which is the internal thermal energy of an object or system which can be transferred to another object or system. Scientists define *heat* as a form of energy that flows between objects or systems due to their temperature difference.

Component 1: Short Review (Time: 7 minutes)

- Ask learners to answer the following questions on their worksheet.

  Q1. What is used to measure temperature?

  Q2. What do you know about 'temperature'?

  Q3. Explain your feeling when a piece of ice is put on your palm for a while.

Ask learners to share their answers and offer positive feedback. Read out a sample answer (from a student or the provided examples) for everyone to listen to and take notes on.

Sample answers:

Q1. A thermometer; a digital temperature sensor or probe, a temperature gauge.

[A common but incorrect answer: *Our hands?* If this is suggested, it might be worthwhile discussing the relative nature of using hands to sense temperature.]

Q2.
- *It's how hot something is; . . . how cold something is; . . . how hot or cold something is.*
- *You can measure it.*
- *It's measured in degrees Celsius; . . . in degrees Fahrenheit (°F); . . . in Kelvin (K).*
- *It is used to tell or predict how hot the day will get.*

Q3. Your hand feels cold under the ice cube and the ice cube begins to melt. Your hand feels cold because heat is moving from your hand to the ice cube and this heat begins to melt the ice cube.

Component 2: **Lesson Purpose** (Time: 3 minutes)

This lesson is about reinforcing that learners can distinguish between *heat* and *temperature*. The two things are different but are closely related. The lessons this week will focus on using examples to help everyone be clear on how, in Science, heat and temperature are different but related concepts.

The lesson in particular may help learners to better understand about heat at the micro or particle level.

Component 3: Lesson Language Practice (Time: 5 minutes)

- Read out difficult or unfamiliar words or phrases and ask the learners to read them to themselves and then out loud as a class, e.g.:

  kinetic energy; thermal energy; heat; temperature; average

- Ask the learners to practice saying the words.

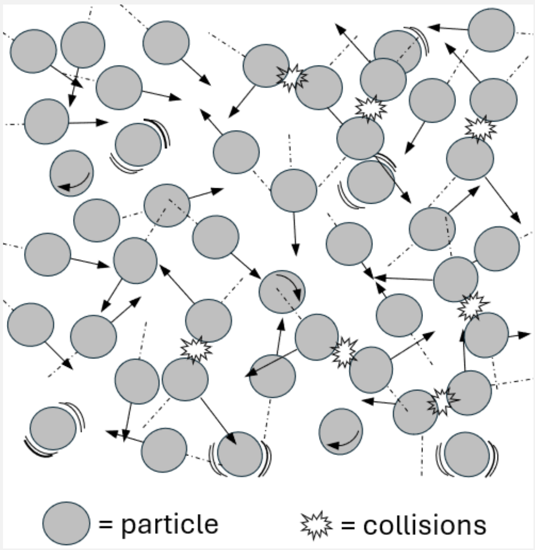
Component 4*:* Lesson Activity (Time: 25 minutes)

Component 4A

- Refer learners to the main lesson stimulus, pointing out that it includes *symbolic representations* of particles of matter that help explain what is happening.

Heat and *Temperature* – they are NOT the same!

Everything around us, including solids, liquids, and gases, has energy due to the motion of the tiny particles that they are made of—*atoms, molecules,* or *ions*. Depending on their state, these particles can vibrate, spin, jostle around and collide with one another because they have kinetic energy. The ***total internal kinetic energy*** of the particles within an object or system represents its ***thermal energy***.



Heat is the part of the internal thermal energy of an object or system that **can be transferred** from one body to another owing to temperature differences. Heat always flows from a higher-temperature object to a lower- temperature object. Because heat is energy, it is measured in units of energy—*joules* (J) or *calories* (cal).

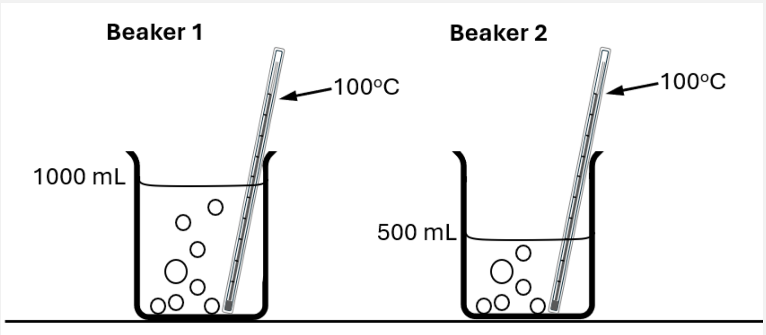
Temperature is a measure of the ***average kinetic energy*** of particles in an object or system, indicating how hot or cold an object or system is. Temperature represents the intensity of thermal energy present in a substance—a higher temperature corresponds to the greater kinetic energy of particles, and so the temperature is measured in units that show intensity—*degrees Celsius* (°C), *degrees Fahrenheit* (°F), or in *Kelvin* (K).

A good way to think about the difference between ***heat*** and ***temperature*** is to consider some practical examples:

Example 1: Compare a cup of 'hot' tea to a 'cool' swimming pool.

A swimming pool at 25°C is at a lower temperature than a cup of 'hot' tea at 70°C. BUT, the swimming pool contains much more water, so it stores much more thermal energy or heat.

Example 2: Compare beakers with different volumes of water, but the same temperature.



Component 4B

Q1. What is the single scientific term that groups *solids, liquids and gases*?

Q2. What are the ways that the particles of matter (atoms, molecules, or ions) move in a substance?

Q3. The heat energy in a substance, or thermal energy, is produced from the collisions of its component particles. Look at the first diagram in the lesson stimulus that depicts the ways that particles in a substance can move. See that some are colliding! Which side of the diagram shows more heat energy – the left side or the right side? Which direction will the heat be transferred if heat moves from the hotter to cooler areas? Explain your answer.

- Observe learners' answers. Ask the learners to volunteer their answers, giving positive feedback. Select a good sample answer for all learners to write down. This may come from the learners or the following sample answer.

Sample answers:

Q1. The states of matter.

Q2.
- *Vibrate.*
- *Spin.*
- *Jostle around.*
- *Collide with one another.*

Q3.
- *The right-hand side of the diagram because it has more collisions represented (6 collisions on the right side compared to 1 on the left side.*
- *Heat will be transferred from the right side to the left side because heat always moves from the hottest part to the cooler part of an object or substance. The hottest part has more collisions occurring, which is on the right side.*

Component 4C

- Read out the following questions and ask learners to answer in the space on their worksheet.

  Q1. What are the units used to measure temperature?

  Q2. Examine the diagram in Example 2. What are the things that are the same for Beaker 1 and Beaker 2?

  Q3. **(Optional)** What can we conclude about the amount of heat present in Beaker1 compared to Beaker 2?

- Observe learners' answers. Ask the learners to share their answers. Give positive feedback. Ask the learners to volunteer their answers, giving positive feedback. Select a good sample answer for all learners to write down. This may come from the learners or the following sample answer.

Sample answers:

Q1. degrees Celsius (°C), or *degrees Fahrenheit* (°F), or *Kelvins* (K).

Q2.
- *Beakers 1 and 2 are the same size.*
- *They both have water in them.*
- *They both have their water boiling.*
- *The water in both beakers is at the same temperature; . . . 100°C*
- *They both have the same type of thermometer.*

Q3.
- *Beaker 1 has twice the amount of heat because it has twice the amount of water.* [Given that everything in this example is the same except for the amount or mass of water, we can conclude that the amount of heat here is dependent on the amount or mass of water – the more mass, the more heat it can store. NOTE: This is why it takes longer to heat or cool large objects compared to smaller ones that are made of the same material.]

Component 5: Lesson Conclusion (Time: 5 minutes)

1. What did you learn from this lesson?
2. What are some things you enjoyed about the lesson?
3. What is something you would like to learn more about in this topic?

REMINDER: Collect learner worksheets to review and analyze learner's knowledge and understanding.

Science Grade 9 Lesson No. 14

Can Heat Do Work for Us?

Key Idea

Heat transfer is one way that the thermal energy of an object or system can be moved to another object. *Work transfer* is the other way that the thermal energy of an object or system can be moved to another object.

Component 1: Short Review (Time: 7 minutes)

- Ask learners to answer the following questions on their worksheet.

  Q1. What is *heat*?

  Q2. List some everyday situations where *work* is done?

  Q3. How is *work* defined in relative to *force* and *distance*?

- Ask learners to share answers. Give positive feedback. Read out a sample answer for all learners to listen to and write down. (This may come from one of the learners or the sample answers below).

Sample answers:

Q1.
- Heat is the transfer of thermal energy (Simple answer)
- *Heat is the part of the internal thermal energy of an object or system that can be transferred from one body to another owing to temperature differences.* (More detailed answer)

Q2.
- *Lifting a book from the floor to a table.*
- *Pushing a shopping cart across a parking lot.*
- *Carrying groceries up a flight of stairs.*
- *Pushing a box along the floor.*
- *Stretching a rubber band.*
- *Pedaling a bicycle.*
- *Climbing a ladder.*
- *Boiling some soup on a stove*
- *Stirring a pot of soup.*

Q3.
- In scientific terms, work is defined as *the transfer of energy that occurs when a force causes an object to move.*
- *The energy needed to make something move* (Simple answer)
- *Work = Force x displacement; or W = F x s* (Mathematical answer)

Component 2: **Lesson Purpose** (Time: 3 minutes)

This lesson is about the transfer of energy through *heat* and *work*.

The lesson may also help learners to reinforce good understanding of the scientific meanings of temperature and heat.

Component 3: Lesson Language Practice (Time: 5 minutes)

- Read out difficult or unfamiliar words or phrases and ask the learners to read them to themselves and then out loud as a class, e.g.:

  heat; work; model; transfer

- Ask the learners to suggest what they understand a 'model' to be. They might have a different answer if you ask: "What is a model in Science?".

Component 4*:* Lesson Activity (Time: 25 minutes)

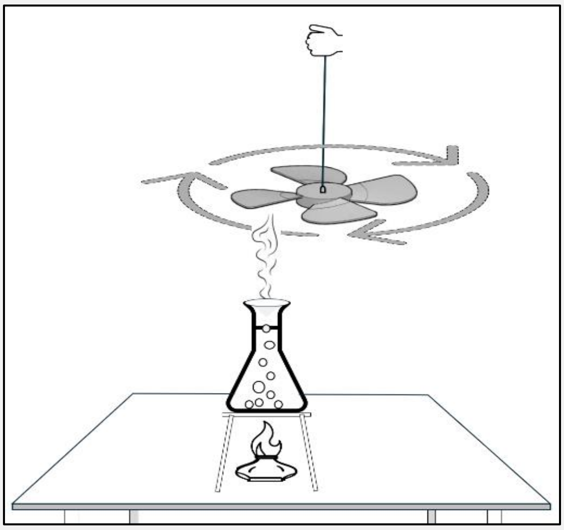
Component 4A

- Refer learners to the main lesson stimulus pointing out that it includes *two models* that help explain the difference between heat and work when we are exploring understanding about thermal energy.

A MODEL TO DEMONSTRATE THAT *HEAT* CAN DO *WORK*

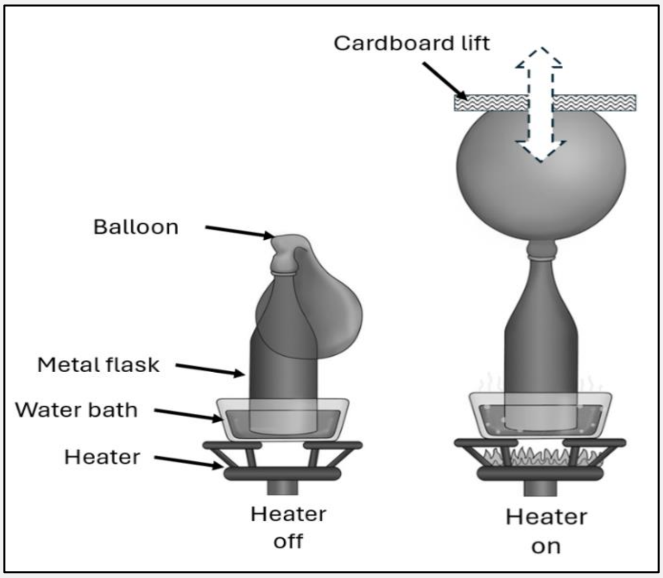
The teacher asked the learners in class to design and construct a model to demonstrate that ***heat*** can do ***work***.

The teacher reminded the class that ***work*** *is the **energy transferred** to or from an object when a **force** moves the object over some **distance*** [W = F x d].



Joseph thought he had a great idea to use an old fan blade off a small electrical fan that he found at home. He attached a string to it so he could hold the fan above a flask of water in his classroom. He used an alcohol lamp to provide heat to boil some water in the flask.

Once the water began to boil, Joseph noticed that there was movement of air above the flask. When he held the fan over above the flask, the fan began to slowly turn.



Ana designed a different model. She thought of using heat to expand a balloon which would then push a cardboard platform upwards. She would put an empty balloon over a metal flask and place that in a water bath that could be heated from below. When the air in the flask was heated, it would expand the air in the flask and the balloon to push her lift up. By turning the heater off, the air in the flask would have less pressure and the balloon would begin to deflate. So the lift would begin to come down again.

Reference: Model 2 adapted from Dynamic Radioisotope Power | Power and Thermal Systems – NASA RPS: Radioisotope Power Systems

Component 4B

- Read out the following questions and ask learners to answer in the space on their worksheet.

  Q1. What provided the heat for Joseph's model??

  Q2. What movements did Joseph detect?

  Q3. How did Joseph relate *heat* to *work*?
- Observe learners' answers. Ask the learners to volunteer their answers, giving positive feedback. Select a good sample answer for all learners to write down. This may come from the learners or the following sample answer.

Sample answers:

Q1. An alcohol lamp.
Q2. 1. Air above the flask.

2. The turning of the fan.

- Some learners might list some movements that occur but do not answer the question*, e.g., The movement of the flame, or the movement of the bubbles in the water.*

Q3. Joseph related that the heat transfer caused a force that pushed the fan to move over a distance as it turned., therefore Heat transfer = F x s = Work.

Component 4C

- Read the following questions and ask learners to answer in the space on their worksheet.

  Q1. In Ana's model, what caused the balloon to move?

  Q2. What is some causes and effects (*Cause → Effect*) that observations that Ana described?

  Q3. **(Optional)** How did Ana relate *heat* to *work*?

- Observe learners' answers. Ask the learners to share their answers. Give positive feedback. Ask the learners to volunteer their answers, giving positive feedback. Select a good sample answer for all learners to write down. This may come from the learners or from the following sample answer.

Sample answers:

Q1. Expanding air in the flask and balloon

Q2.
- *Heat from the burner to heat in the water bath.*
- *Heat in the water to expanding air in the flash.*
- *Expanding air in the flask to expanding air in the balloon.*
- *The expanding balloon lifting the cardboard platform.*
- *Reducing the heat, causing the cardboard platform to lower.*

Q3.
- *Ana related that the heat transfer caused a force that expanded the air in the flask and the balloon causing the balloon to move up over a distance to push the cardboard platform, therefore there is heat transfer.* [Heat transfer = F x s = Work]
- *There is also Work Transfer – the work done by the balloon is transferred to the cardboard platform.*

THESE ARE BOTH EXAMPLES OF ENERGY TRANSFER.

Component 5: Lesson Conclusion (Time: 5 minutes)

Remind that good learners reflect on their learning.

- The focus of this lesson was on heat and work transfer- examples of ENERGY TRANSFER.
- Ask learners to answer the following questions either by class discussion or writing the answers in their worksheet.

  Q1. Has this lesson helped you to better understand energy transfers*? If so, how?*

  Q2. Has this lesson helped you to remember what heat and work are? If so, how?

  Q3. What was hard to do or understand in the lesson?

REMINDER: Collect learner worksheets to review and analyze learner's knowledge and understanding.

Science Grade 9 Lesson No. 15

Transferring Heat

Key Idea

Conduction, *convection* and *radiation* are the main three ways to transfer heat but they all transfer heat in different ways.

Component 1: Short Review (Time: 7 minutes)

- Ask learners to answer the following questions on their worksheet.

  Q1. What does the word 'transfer' mean?

  Q2. What are three ways that heat can be transferred from one place to another?

  Q3. Explain what is needed if heat is to be transferred?

Ask learners to share their answers and offer positive feedback. Read out a sample answer (from a student or the provided examples) for everyone to listen to and take notes on.

Sample answers:

Q1. Move from one place to another, or *shift something,* or *Change from one office to another*

Q2.
- *Conduction*
- *Convection*
- *Radiation*

Q3. Three possible answers (anyone is excellent)
- *Particles in a solid (for conduction)*
- *Particles in a liquid or gas (for convection)*
- *Electromagnetic waves if it is radiated*

Component 2: **Lesson Purpose** (Time: 3 minutes)

This lesson is about the three main ways that heat is transferred in everyday situations.

The lesson may also help learners to better understand what heat transfer means.

Component 3: Lesson Language Practice (Time: 5 minutes)

- Read out difficult or unfamiliar words or phrases and ask the learners to read them to themselves and then out loud as a class, e.g.:

Conduction; Convection; Radiation

- Ask the learners to practice saying the words.
- Discuss the form of the words:
  e.g. *The three terms have the same ending* ***'…tion'.***
  Lots of technical science words have this ending. What does that indicate about the words?

[Suggested explanation: The suffixes "-tion" and "-sion" are both used to create **nouns** from **verbs** to describe a state, condition, action, process, practice, or result. These are common situations that occur when we are describing or explaining the natural or made physical world in science.]

Component 4*: *Lesson Activity (Time: 25 minutes)

Component 4A

- Refer learners to the main lesson stimulus pointing out that it includes three definitions plus a practical everyday example of ways heat can be transferred.

Three ways that heat is transferred

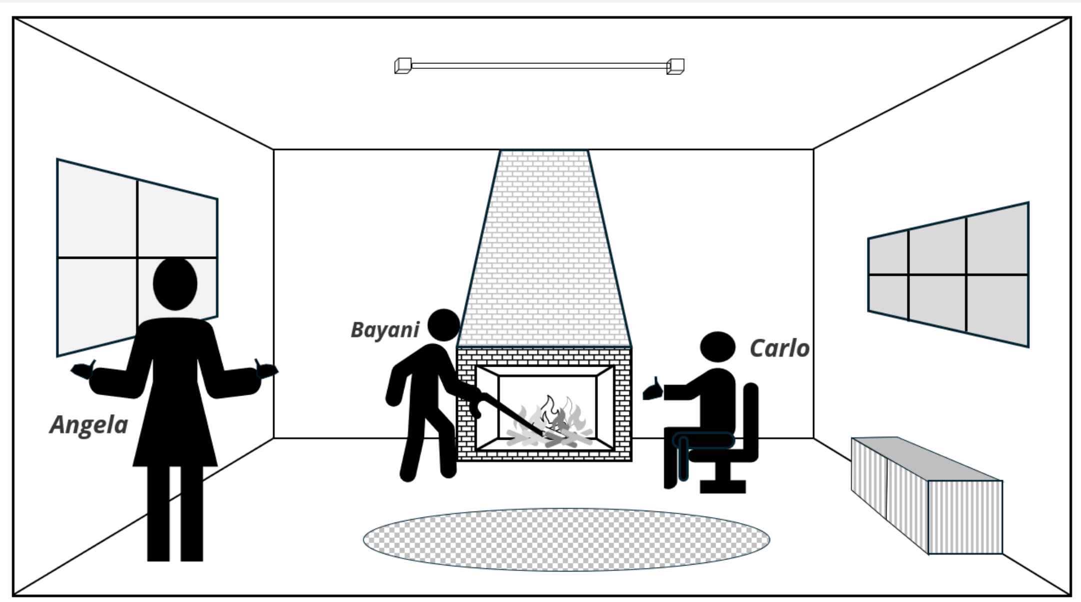
Conduction is the process of thermal transfer either within an object or between a hot object and a cooler object when they come in direct contact with each other. Heat is transferred by increasing the motion of the particles in solid objects. It happens best in solids, especially metals. Although conduction can occur in liquids and gases, it is much slower than in solids.

Convection is the process of thermal transfer when the heat from a hot object or heat source is carried by the movement of a heated liquid or gas, such as water or air. The heated liquid or gas rises, carrying the heat in its particles.

Radiation is the process of thermal transfer through infrared electromagnetic waves. This transfer of heat does not require a substance, or medium, to carry the heat energy. Heat travels directly and quickly to cooler objects nearby. This includes any nearby gas or liquid particles (atoms or molecules).

It can get really hot in a room with an open fireplace!

On a very cold night, three friends, **Angela**, **Bayani** and **Carlo**, walked into a room where an open fire had just been started. They were fascinated with the fire and the heat it was creating in the room.



Carlo, who was sitting close to the fire, said "Wow, I can feel the heat on my hands as soon as I sat down!". **Bayani** had a long metal poker to move the burning logs around. After a few minutes, Bayani said "Guess what? I can feel heat in the metal poker now – it's getting too hot to hold!". **Angela** was standing well away from the fire and could not feel any heat directly. After about 10 minutes, Angela said "I can feel the air getting warmer over here. It feels like it's coming from the ceiling!".

Component 4B

- Read out the following questions and ask learners to answer in the space on their worksheet.

  Q1. What heat transfer is caused by conduction?

  Q2. What types of particles can transfer heat?

  Q3. How is the way that heat is transferred by radiation different from the way it is transferred by conduction and convection?

- Observe learners' answers. Ask the learners to share their answers. Give positive feedback. Select a good sample answer for all learners to write down. This may come from the learners or the following sample answer.

Sample answers:

Q1. The transfer of heat by the increased motion of the particles in solid objects.

Q2.
- *Particles in solids.*
- *Particles in liquids.*
- *Particles in gases.*

Q3. The transfer of heat by conduction and convection requires the presence of particles such as atoms and molecules, whereas the transfer of heat by radiation does not require a medium – it can travel in a vacuum.

Component 4C

- Read the following questions and ask learners to answer in the space on their worksheet.

  Q1. What produces the heat in the room that Angela, Bayani and Carlo are in?

  Q2. What are the ways that Angela, Bayani and Carlo feel heat in the room?

  Q3. **(Optional)** From the information provided, what is the fastest and slowest way that heat moves?
- Observe learners' answers. Ask the learners to volunteer their answers, giving positive feedback. Ask the learners to volunteer their answers, giving positive feedback. Select a good sample answer for all learners to write down. This may come from the learners or the following sample answer.

Sample answers:

Q1. The burning of wood fuel.

Q2.
- *Carlo feels the heat directly from the fire.*
- *Bayani feels the heat moving through the long metal poker that has its pointy end in the fire.*
- *Angela feels the heat as the air gets warmer.*

Q3.
- *Radiation is the fastest way that the heat moves or is transferred (Carlo feels it immediately)*
- *Convection is the slowest way that the heat moves or is transferred (Angela feels it after 10 minutes)*
- *Heat moves or is transferred by conduction at a moderate rate (Bayani feels it after a few minutes)*

Component 5: Lesson Conclusion (Time: 5 minutes)

Remind that good learners reflect on their learning.

The focus of the lesson was on understanding more deeply about three ways to transfer heat.

1. How has the lesson helped you to better understand the role of particles in transferring heat?
2. Which questions were easy to answer – the ones in Component 4B or Component 4C? Why?
3. What strategies do you use to answer the harder questions?

REMINDER: Collect learner worksheets to review and analyze learner's knowledge and understanding.

Science Grade 9 Lesson No. 16

Heat Transfer in a Kitchen Oven

Key Idea

An electric oven is an application that utilizes all the ways that heat energy can be transferred, or moved. It is also a good application to demonstrate how electrical energy can be transformed, or changed, into heat energy.

Component 1: Short Review (Time: 7 minutes)

- Ask learners to answer the following questions on their worksheet.

  Q1. What does 'heat transfer' mean?

  Q2. What are the ways that heat can be transferred?

  Q3. What is the **energy change** (or *transformation*) that occurs in a kitchen oven?

Ask learners to share their answers and offer positive feedback. Read out a sample answer (from a student or the provided examples) for everyone to listen to and take notes on.

Sample answers:

Q1.
- *Moving heat;*
- *Moving heat from one place to another;*
- *Transporting heat energy;*

Q2.
- *Convection;*
- *Conduction;*
- *Radiation, as radiated heat*

Q3.
- *Electrical energy* **is transformed to** *heat energy* [Electrical → Heat]

Component 2: **Lesson Purpose** (Time: 3 minutes)

This lesson is about how household appliances produce heat to do work and how the heat is transferred from the oven to the food.

The lesson may also help learners to better recall the differences between *conduction*, *convection* and *radiation*.

Component 3: Lesson Language Practice (Time: 5 minutes)

- Read out difficult or unfamiliar words or phrases and ask the learners to read them to themselves and then out loud as a class, e.g.:

electric oven; heating element; roasting tray

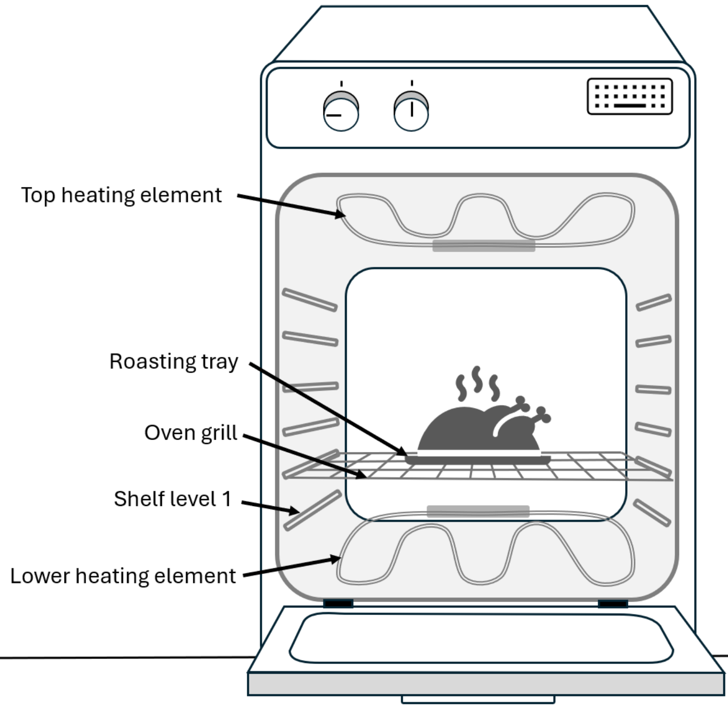
- Ask the learners to practice saying the words.

Component 4*:* Lesson Activity (Time: 25 minutes)

Component 4A

- Refer learners to the main lesson stimulus pointing out that it uses a labeled diagram and brief text to convey scientific information about an everyday appliance.

THREE WAYS THAT HEAT ENERGY IS TRANSFERRED



AN ELECTRIC OVEN
with two heating elements
and 6 shelf levels

Heating processes:

Radiation happens directly from the heating elements with heat traveling in straight wave fronts to the oven walls, the metal grill, the metal roasting tray and to the food being cooked.

Conduction happens through the metal heating elements, and when heat travels through the oven grills, through the roasting tray and to the food being cooked.

Convection happens when the air around the heating elements gets hot – it rises and circulates to heat the air in the oven.

Component 4B

- Read out the following questions and ask learners to answer in the space on their worksheet.

  Q1. What is the name of the process of thermal transfer that involves heat being directly transferred to other objects without the need for a medium to carry the heat energy?

  Q2. List some everyday examples that demonstrate the ***convection*** of heat energy?

  Q3. How are ***convection*** and ***conduction*** most significantly different from ***radiation***?

- Observe learners' answers. Ask the learners to share their answers. Give positive feedback. Select a good sample answer for all learners to write down. This may come from the learners or the following sample answer.

Sample answers:

Q1. Radiation.

Q2.
- *Boiling water in a container.*
- *A hot air balloon.*
- *Sea and land breezes.*
- *Air conditioning.*
- *The cooling of the air in a refrigerator.*
- *The radiator in a room, a car or a truck.*
- *Thunderstorms.*

Q3. Good and acceptable sample answers:

- *To transfer heat, convection and conduction both require a medium of particles, such as atoms, or molecules*

or

- *Radiation is the direct transfer of heat without the need for any particles. Convection and conduction cannot occur in a vacuum.* [FROM LAST LESSON: Radiation is by infrared electromagnetic waves that can travel through a vacuum or space.]

Component 4C

- Read the following questions and ask learners to answer in the space on their worksheet.

  Q1. What is the name of the process of thermal transfer that involves heat traveling through the oven grills, through the roasting tray and then to the food being cooked?

  Q2. List things that would get hot in an electric oven due to ***radiation***.

  Q3. **(Optional)** If a person wanted to make some toast or chargrill some bread in a tray, which heating element (top or lower) and which shelf level would be best to use? Explain your reasoning?

- Observe learners' answers. Ask the learners to volunteer their answers, give positive feedback. Select a good sample answer for all learners to write down. This may come from the learners or the following sample answer.

Sample answers:

Q1. Conduction.

Q2.
- *The heating elements.*
- *The oven grills.*
- *The roasting tray.*
- *THE food being cooked.*
- *The air in the oven.*
- *The walls of the oven.*
- *The glass door of the oven.*

Q3. It would be best to use the top element with the tray set on Shelf level 6. This would keep the bread close to the top element so the bread would be quickly charred by radiant heat, rather than being cooked slowly by convection.

Component 5: Lesson Conclusion (Time: 5 minutes)

1. Could you find any answers in the Stimulus text provided for questions in Component **4B** or **4C**? Which ones?

   Learners can find direct answers to 4B Q1 and Q3.

2. What connections or differences do you notice between questions in **4B** and **4C.**
3. Did you find it easier to answer the questions in Component **4B** or **4C**? Why?

> e.g., It can be helpful to explain to learners that it is good learning technique to look for answers that might be given in a text or stimulus. This also helps understanding what is needed to answer questions.

REMINDER: Collect learner worksheets to review and analyze learner's knowledge and understanding.

Science Grade 9 Lesson No. 17

Generating Electricity for Household, Commercial and Industrial Use in the Philippines

Key Idea

The processes of heat transfer and energy transformations are fundamental processes for generating electricity at large scale in the Philippines for household, commercial and industrial uses.

Component 1: Short Review (Time: 7 minutes)

- Ask learners to answer the following questions on their worksheet.

  Q1. Is switching on an electric light an example of an ***energy transfer*** or an ***energy transformation***?

  Q2. What are some common devices that can transform electrical energy into heat energy?

  Q3. How can *movement energy* (*Kinetic energy*) be transformed into *electrical energy*?

Ask learners to share their answers and offer positive feedback. Read out a sample answer (from a student or the provided examples) for everyone to listen to and take notes on.

Sample answers:

Q1. An energy transformation. [Electrical energy → light energy]

Q2.
- *an electrical heater*
- *A toaster;*
- *An electrical frying pan.etc.*

Q3. Using a device such as a generator or an alternator that will convert mechanical energy into electrical energy. In a hydroelectric power plant, water flowing over a turbine causes it to rotate, which in turn rotates a generator to produce electricity. In the generator, an electrical conductor such as a wire coil must move through a magnetic field which will induce an electric current in the wire.

Component 2: **Lesson Purpose** (Time: 3 minutes)

This lesson is about helping learners to understand the scientific difference between *energy transfer* and *energy transformation.* The lesson uses technical scientific diagrams that show *processes* and *devices* where energy changes occur.

The lesson should help learners to better understand how *heat* does *work,* but also how to *interpret* and *summarize* information.

Component 3: Lesson Language Practice (Time: 5 minutes)

- Read out difficult or unfamiliar words or phrases and ask the learners to read them to themselves and then out loud as a class, e.g.:

boiler; turbine; generator; transformer; condenser

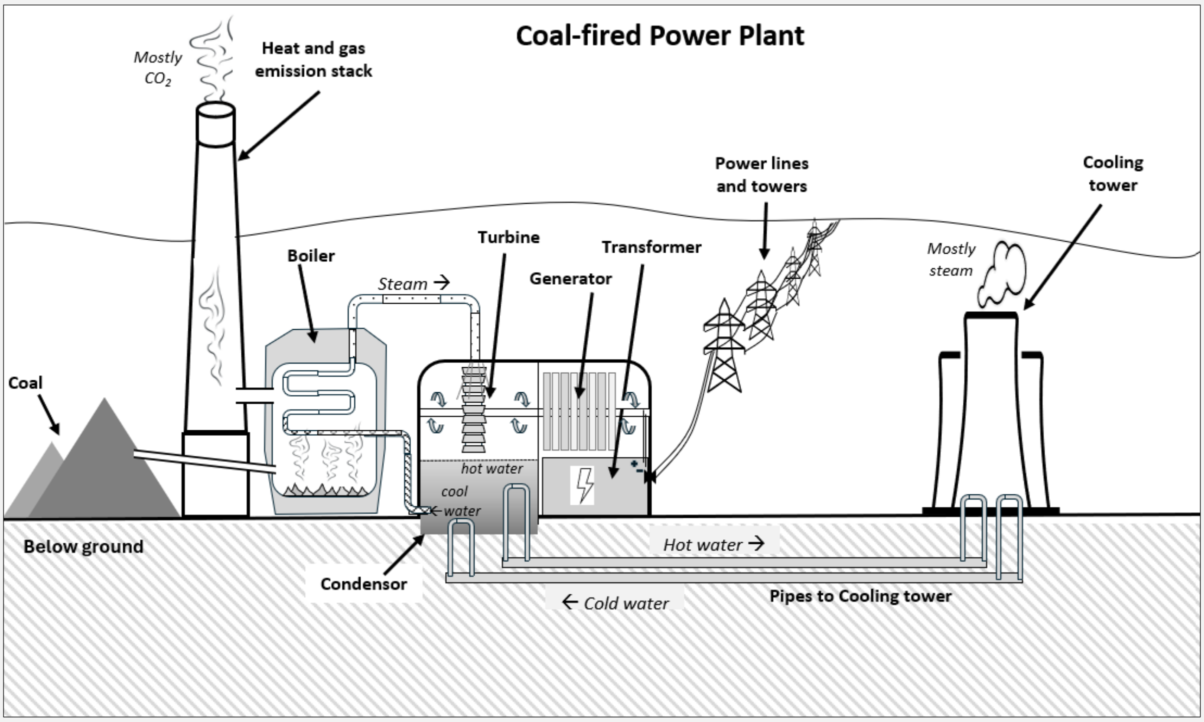
These are all industrial devices used in large power plants to generate electricity, Are there household examples of them as well?

Component 4*:* Lesson Activity (Time: 25 minutes)

Component 4A

- Refer learners to the main lesson stimulus pointing out that it uses a cross-sectional diagram to describe and explain a complex system.

How a coal-fired power plant works



- **Coal** is *burned* to produce *heat* in the **boiler**.
- Heat in the boiler is *transferred* to a **system of tubes** in the boiler that contain **water**.
- The heat in the tubes *changes* the **water** to **steam,** which builds high pressure in the tubes.
- When the pressure is released against the blades of the **turbine**, a *force* is produced**.**
- The force of the steam *pushes* on the blades of the turbine making the turbine *spin* rapidly.
- The rotating turbine is directly connected to the **generator** which *spins* rapidly to produce *electricity*.
- The electricity is *transferred* to the **transformer** which increases the *voltage* for transmission to for household, commercial, and industrial uses.
- The steam in the system of tubes is *turned back* to water in the **condenser** for recirculation in the boiler.
- The condenser uses cold water from the **cooling tower** to turn the steam back to water.

Component 4B

- Read out the following questions and ask learners to answer in the space on their worksheet.
  Q1. What is the main ***source of heat*** in the power plant?
  Q2. One ***energy transformation*** that occurs in the power plant is:
  Chemical energy → Heat energy [coal burning in the Boiler].
  What **other energy transformations** can you identify that occur in the power plant?
  Q3. Describe where heat energy is ***transferred*** (but not transformed into a different form of energy)?
- Observe learners' answers. Ask the learners to share their answers. Give positive feedback. Select a good sample answer for all learners to write down. This may come from the learners or from the following sample answer.

Sample answers:

Q1. Coal, or better *the burning of coal*

Q2. • ***Heat energy → Movement energy*** *(Mechanical energy or Kinetic energy)* [Steam turning the Turbine blades]

- ***Movement energy → Electrical energy*** [in the Generator]

Q3.
- *Heat is transferred from the flames in the boiler to the system of tubes in the boiler that contain water.*
- *Heat is transferred from the water in the system of tubes as it is converted to steam in the tubes.*
- *In the condenser, heat is transferred from the water in the system of tubes as it is converted to steam in the tubes*

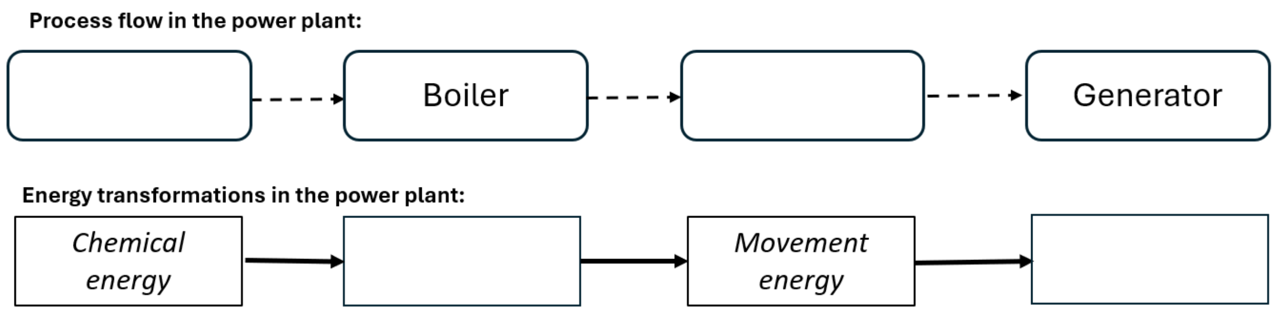
Component 4C

- Read out the following questions and ask learners to answer in the space on their worksheet.

  Q1. What substance carries heat from the boiler to the turbine?

  Q2. What are the waste products of a coal-fired power plant?

  Q3. **(Optional)** Complete the energy transformation summary by adding scientific terms to the flow chart provided in your worksheet



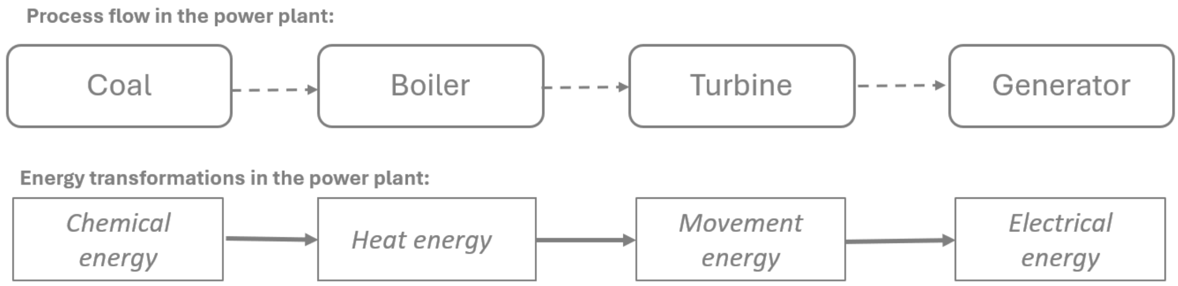
- Observe learners' answers. Ask the learners to share their answers. Give positive feedback. Ask the learners to volunteer their answers, giving positive feedback. Select a good sample answer for all learners to write down. This may come from the learners or from the following sample answer.

Sample answers:

Q1. Water (liquid water and water vapor or steam)

Q2.
- *Carbon dioxide (CO2).*
- *Other gas emissions like sulfur dioxide* (SO_2), methane (CH_4) and nitrogen oxides (e.g. NO_2).
- *Heat*
- *Steam*
- *Ash*
- *Smoke and soot*
- *Coal dust.*

Q3. Sample answered flow chart:



Component 5: Lesson Conclusion (Time: 5 minutes)

*The focus of the lesson was on learning about the scientific difference between **energy transfer** and **energy transformation**.*

1. What did you learn from this lesson?
2. What are some things you enjoyed about the lesson?
3. What have you learned from this topic?

REMINDER: Collect learner worksheets to review and analyze learner's knowledge and understanding.

Science Grade 9 Lesson No. 18

Comparing Fossil Fuels to Geothermal Sources of Heat to Generate Electricity

CONSOLIDATION LESSON

Component 1: Short Review (Time: 7 minutes)

- Ask learners to answer the following questions on their worksheet.

  Q1. What is geothermal energy?

  Q2. What are some common fossil fuels?

  Q3. What are the advantages of using geothermal sources of heat?

Ask learners to share their answers and offer positive feedback. Read out a sample answer (from a student or the provided examples) for everyone to listen to and take notes on.

Sample answers:

Q1. Geothermal energy is a form of renewable energy derived from the heat stored beneath the Earth's surface. This heat originates from the Earth's core, where temperatures can reach several thousand degrees Celsius due to radioactive decay of minerals. Geothermal energy can be harnessed for various purposes, including electricity generation, heating, and cooling.

Q2.
- *Coal*
- *Natural gas;*
- *Oil*
- *Charcoal*
- *Petrol*
- *Diesel*

Q3. It is cleaner and more environmentally sustainable; It is renewable; It is not affected by day/night, weather or the seasons.

Component 2: **Lesson Purpose** (Time: 3 minutes)

This lesson is about looking for similarities and differences in how electricity is generated by the use of fossil fuels compared to geothermal sources of heat.

The lesson may also help learners to consolidate ideas about heat transfer and transformations involving heat.

Component 3: Lesson Language Practice (Time: 5 minutes)

- Read out difficult or unfamiliar words or phrases and ask the learners to read them to themselves and then out loud as a class, e.g.:

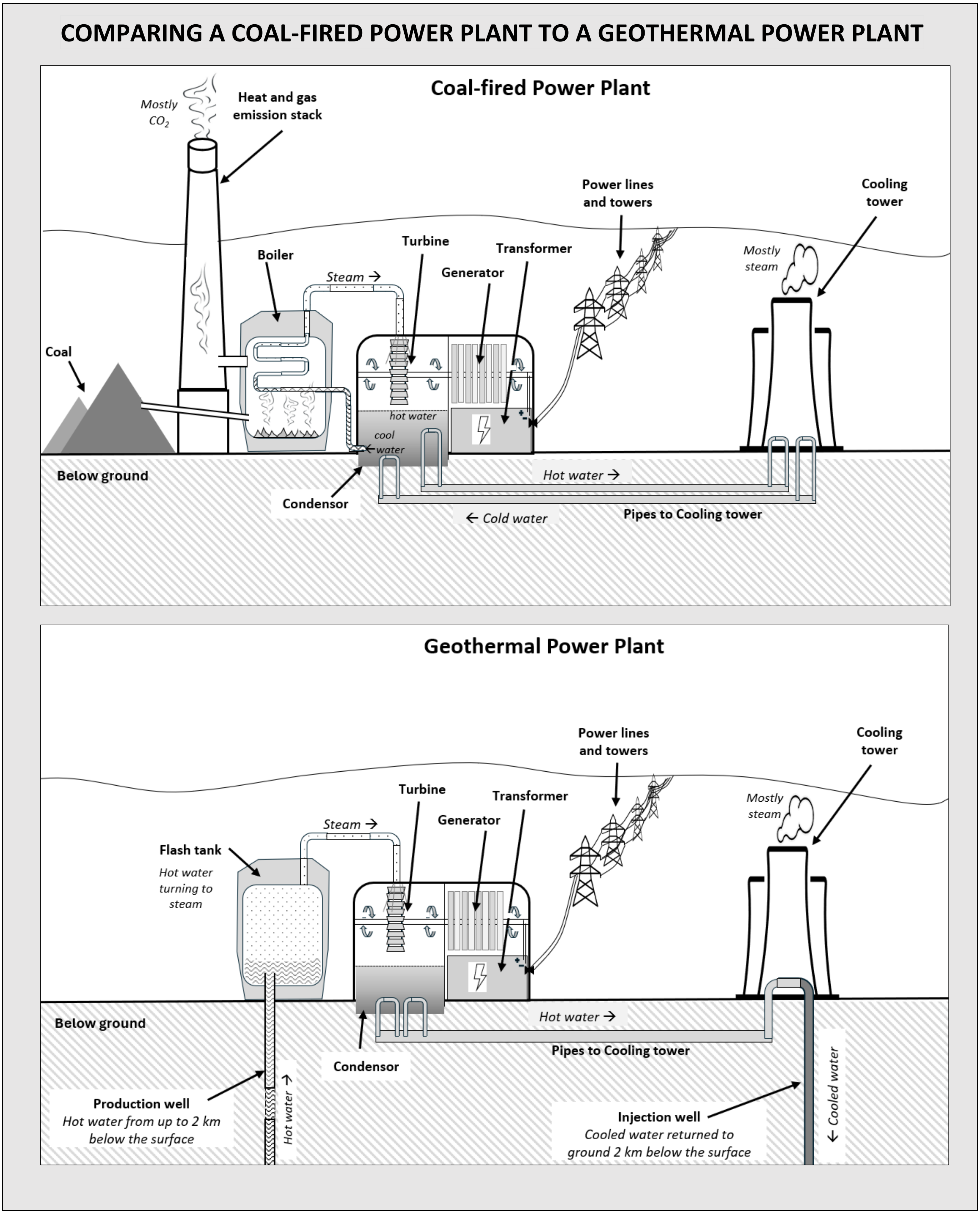
Production well; injection well

- Ask the learners to practice saying the words.
- Unpack the possible meaning of the terms. It should help if the teacher mentions that a well is a deep hole that engineers have drilled into the hot ground near volcanoes.

Component 4*:* Lesson Activity (Time: 25 minutes)

Component 4A

- Refer learners to the main lesson stimulus, pointing out that the diagrams are cross-sections that summarize the key components and processes of two types of electricity generation power plants that are used in the Philippines.



Component 4B

- Read the following questions and ask learners to answer in the space on their worksheet.

Q1. On the two diagrams that compare a coal-fired power plant to a geothermal power plant, use a colored pencil to shade all the parts that the two power plants have in common. This will make it obvious which parts are the same and which parts are different.

Q2. The following table describes the parts, functions and waste products of the two power plants. Use the same colored pencil to highlight the parts that are the same in the two

Coal-fired Power Plant	Geothermal Power Plant
Heat source: *Coal*, which is crushed to a fine powder and burned in the boiler to produce steam.	**Heat source:** *Hot water* from deep underground reservoirs near volcanoes is tapped with deep pipes to bring it up 2 km to the surface.
Steam generation system: A *Boiler* where heat is exchanged in layers of pipes to turn the turbine-water into steam. An emission stack takes away leftover heat and gases.	**Steam generation system:** A *Flash tank* where the reduced pressure causes the hot water from underground to boil rapidly or "flash" into vapor.
Turbine: Steam coming from the Boiler drives a turbine, generating mechanical energy.	**Turbine:** Steam from the Flash tank drives a turbine, generating mechanical energy.
Generator: The turbine is connected to a generator, which converts mechanical energy into electrical energy.	**Generator:** The turbine is connected to a generator, which converts mechanical energy into electrical energy.
Transformer: Increases the voltage ready to be distributed through the power lines to for household, commercial and industrial uses.	**Transformer:** Increases the voltage ready to be distributed through the power lines to for household, commercial and industrial uses.
Condenser: Steam from the turbine is condensed back into hot water.	**Condenser:** Steam from the turbine is condensed back into hot water.
Cooling tower: Cools the hot water from the steam turbine.	**Cooling tower:** Cools the hot water from the steam turbine.
Emissions: Approximately 1000 grams of CO_2 per kilowatt-hour; Approx. 3 grams per kilowatt-hour of sulfur dioxide (SO_2), methane (CH_4) and nitrogen oxides (e.g. NO_2). Significant articulate matter, smoke and soot. Heat from the working machinery; Heat and steam from cooling towers.	**Emissions:** Approximately 50 grams of CO_2 per kilowatt-hour; Approx. 0.03 grams per kilowatt-hour of sulfur dioxide (SO_2), methane (CH_4) and nitrogen oxides (e.g. NO_2). Insignificant particulate matter, smoke and soot. Heat from the working machinery; Heat and steam from cooling towers.
Other waste: Ash produced from burning coal is collected and disposed of in land fill or recycled in concrete making.	**Other waste:** Used geothermal fluid is reinjected into the reservoir after any mercury is filtered out.

Q3. Which power plant appears to have the smallest impact on the environment? Explain your answer with evidence from the table in Question 2.

- Observe learners' answers. Ask the learners to share their answers. Give positive feedback. Select a good sample answer for all learners to write down. This may come from the learners or the following sample answer.

Sample answers:

Q1. Learners should at least color the Turbine, the Generator, the Transformer and powerlines, the Condenser and the Cooling tower. They might reasonably color the Boiler/Flash tank as they serve the same purpose.

Q2. Table cell to color (The second row shows the same process but uses different technology):

Coal-fired Power Plant	Geothermal Power Plant
Heat source: *Coal*, which is crushed to a fine powder and burned in the boiler to produce steam.	**Heat source:** *Hot water* from deep underground reservoirs near volcanoes is tapped with deep pipes to bring it up 2 km to the surface.
Steam generation system: A *Boiler* where heat is exchanged in layers of pipes to turn the turbine-water into steam. An emission stack takes away leftover heat and gases.	**Steam generation system:** A *Flash tank* where the reduced pressure causes the hot water from underground to boil rapidly or "flash" into vapor.
Turbine: Steam coming from the Boiler drives a turbine, generating mechanical energy.	**Turbine:** Steam from the Flash tank drives a turbine, generating mechanical energy.
Generator: The turbine is connected to a generator, which converts mechanical energy into electrical energy.	**Generator:** The turbine is connected to a generator, which converts mechanical energy into electrical energy.
Transformer: Increases the voltage ready to be distributed through the power lines to for household, commercial and industrial uses.	**Transformer:** Increases the voltage ready to be distributed through the power lines to for household, commercial and industrial uses.
Condenser: Steam from the turbine is condensed back into hot water.	**Condenser:** Steam from the turbine is condensed back into hot water.
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Emissions: Approximately 1000 grams of CO_2 per kilowatt-hour; Approx. 3 grams per kilowatt-hour of sulfur dioxide (SO_2), methane (CH_4) and nitrogen oxides (e.g. NO_2). Significant articulate matter, smoke and soot. Heat from the working machinery; Heat and steam from cooling towers.	**Emissions:** Approximately 50 grams of CO_2 per kilowatt-hour; Approx. 0.03 grams per kilowatt-hour of sulfur dioxide (SO_2), methane (CH_4) and nitrogen oxides (e.g. NO_2). Insignificant particulate matter, smoke and soot. Heat from the working machinery; Heat and steam from cooling towers.
Other waste: Ash produced from burning coal is collected and disposed of in land fill or recycled in concrete making.	**Other waste:** Used geothermal fluid is reinjected into the reservoir after any mercury is filtered out.

Q3. An answer that identifies the Geothermal power plant and includes two reasons is sufficient.

- *The Geothermal power plant appears to have the smallest impact on the environment because it:*
  - *does not require coal that is mined from the ground and stockpiled near the power plant,*
  - *does not produce as much carbon dioxide waste (< 1% of the coal-fired plant),*
  - *does not emit very much of other toxic gases, such as sulfur dioxide (SO^2), methane (CH^4) and nitrogen oxides (e.g. NO^2),*
  - *does not create other solid waste, such as ash that has to be buried in the ground or recycled in concrete,*
  - *does not create soot that spoils the air and surrounding environment.*

Component 4C

- Read out the following questions and ask learners to answer in the space on their worksheet.

  Q1. What is the function of the transformer in the two electricity power plants?

  Q2. How is water used in the two electricity power plants?

  Q3. **(Optional)** Explain how the flash tank makes use of the scientific relationship between *heat* and *pressure.*

- Observe learners' answers. Ask the learners to sharer their answers. Give positive feedback. Ask the learners to volunteer their answers, giving positive feedback. Select a good sample answer for all learners to write down. This may come from the learners or the following sample answer.

Sample answers:

Q1. The function of the transformer is to step up or increase the voltage of the electricity (so it can be transported along the high voltage wires to where it is to be used).

Q2.
- *As the heat exchange fluid in the water-steam pipes of the boiler in the Coal-fired plant.*
- *As the heat source in the Geothermal plant.*
- *The coolant is used to turn steam back to water in both power plants.*

Q3. The hot water from the production well comes up under high pressure. When it enters the flash tank there is a big reduction in pressure which causes a massive increase in the heat of the water so the water then boils rapidly or "flashes" into vapor (hot steam). [For some very mathematically minded learners, the teacher could use the *pressure/volume/temperature* relationship and equation (**pV=nRT**) to explain the relationship.]

Component 5: Lesson Conclusion (Time: 5 minutes)

The focus of the lesson was on understanding more deeply and identifying the similarities and differences in how electricity is generated by the use of fossil fuels compared to geothermal sources of heat.

1. How has the lesson helped you to consolidate ideas about heat transfer and transformations involving heat?
2. Which questions were easy to answer – the ones in Component 4B or Component 4C? Why?
3. What strategies do you use to answer the harder questions?

REMINDER: Collect learner worksheets to review and analyze learner's knowledge and understanding.

For inquiries or feedback, please write or call:

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