Teaching Some Selected Topics of

Based on National Chemistry Curriculum

Ethiopian Teachers Association (ETA)

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The delivery of quality and equitable science and mathematics education has been the focus of attention for countries like Ethiopia, which are struggling to drag themselves out of poverty and backwardness. In this regard the Ministry of Education has been doing its level best to improve the performance of the education sector since the past twenty years. Among the many efforts are the aggressive measures taken to improve the quality of the general education through publishing attractive textbooks, rationalizing content load and content difficulty and implementation of student centered approaches.

Besides this focus of the government on quality of education, there are still many challenges that contribute to poor quality of lessons of the various subjects taught in our schools. Some of the major challenges include the shortage and low quality of teaching resources. Though the ministry of education is recently trying to institutionalize teacher professional development activities through school based CPD programs. Lack of sufficient training opportunities for teachers to update their skills in light of the modern methods of teaching and learning is also the other challenge. It is to be recalled that teachers equipped with modern and innovative teaching methods play a significant role in the provision of quality education.

Conversely, teachers who are ill prepared and less invested with are likely to use inappropriate teaching methods that may result in students' misconception of the taught idea. Therefore, in order to curb this undesirable possibility, it is important to keep teachers up-to-date in their subject and profession through continuous professional development endeavors.

Other complementary support to teachers include direct suggestions of instructional strategies to improve lessons., The strategies should challenge preconceptions and school-made misconceptions through recommending alternatives to the traditional approaches, such as setting up simplified laboratory experiments, use of structural models and technology-based methods.

Chemistry is one of the most important branches of science; it enables learners to understand what happened around them. Because chemistry topics are generally related to or based on the structure of matter, chemistry proves a difficult subject for many students. Chemistry curricula commonly incorporate many abstract concepts, which are central to further learning in both chemistry and other sciences. These abstract concepts are important because further chemistry/science concepts or theories cannot be easily understood if these underpinning concepts are not sufficiently grasped by the student

To this end, it is important to highlight that , the multi dimensional and deep rooted problems in provision of quality education in our schools cannot be resolved by the efforts of the government alone It requires the active participation of the community , especially professional associations which hold a substantial stake in education.

This manual is therefore the result of the grand initiative taken by ETA to contribute its part in the improvement of the teaching and learning process in schools.

ETA took initiative of developing an alternative approaches of a web based science and mathematics teaching. Thus, the material is expected to play a remarkable role in giving the grade 9 chemistry teachers the opportunity to use alternative methods.

Provision of interactive science and mathematics lessons in schools plays a significant role in enhancing the growth of a country's science and technology in particular and the economic development in general. Strengthening of these lessons require planned interventions in all dimensions of the teaching and learning process. Using communication technology in education is one of such efforts since it provides interactivity and simplicity to concretize the delivery of lessons.

The main objectives of this manual are to:

- Provide alternative methods of teaching for grade 9 chemistry teachers;
- Create opportunity of communication among the teachers on the issues of teaching chemistry

The manual is hoped to serve one of the two purposes: the lessons presented in the manual can directly be used by the teacher in the classroom, or they can be used as model to prepare lessons for the contents. The teacher can therefore download the lessons before the class, analyzes the design to internalize the approach and use it directly or with some modifications if necessary. What the teacher supposed to do are

- Organize the materials listed in the lesson
- Write down lesson plan based on the lesson provided

You may use a lesson plan format adapted from SMASEE (Strengthening Mathematics and Science Education in Ethiopia) which is under pilot and now upgrading. A sample plan is prepared and annexed at the end of the manual for the second lesson of the unit 2, Structure of the Atom. Please look at the lesson on page – of this manual and analyze how it is related to the plan.

It is not possible to suggest teaching methods for the whole lessons of grade 9 chemistry course in this limited pages manual. Some 'difficult' representative contents of each unit are selected using expert judgment basically depending on abstractness of a topic and misconceptions students may acquire during a lesson. The unavailability of teaching materials in schools is the other criterion for the selection of the topics for treatment in this manual. If such topics are treated using some model teaching approaches, it is believed that the remaining similar contents can be taught in the same way.

Selected contents

No	Unit	Lesson Content
1	Structure of the Atom	• The Dalton's Atomic Theory • Discovery of Electron • Atomic number and mass number and Atomic mass, and isotope • The atomic Models • The Quantum mechanical Model
2	Periodic Classification of the Elements	• The modern Periodic Law • Classification of the elements • Periodic Properties in the Periodic Table • Project work on the periodic table (Individual Task)
3	Chemical Bonding and Intermolecular Forces	• Introduction to Chemical Bonding • Formation of Ionic Compounds • Properties of ionic compounds • Inter molecular forces
4	Chemical Reaction and Stoichiometry	• Introduction to chemical reaction • Balancing Chemical Reactions • Types of Chemical Reactions • Limiting and excess reactant • Oxidation reduction reaction • Rate of Chemical Reactions
5	Physical State of Matter	• Properties of Gases and kinetic molecular theory of gases • Vapour Pressure • Phase change and Energy Change in Solids

Table int. 1

When necessary, some brief notes are given in the manual at the beginning of the lessons. Moreover, the following general pints are advised for teachers to note during the planning and delivery of lessons.

When planning a lesson, the focus should be on how students learn not on how the teacher teaches. This means that the teacher should device in his/her plan activities which challenge the students in their learning. The activities should be motivating enough for the students to participate in the lesson with their minds, hands, tongues and hearts on. The activities should engage students in critical thinking, provide something to be done by their hands, and assist them to make decisions or bring about change in attitude. Unlike telling or informing facts, teachers require creativity in order to lead students into an investigation of a concept.

Care should be taken when activity is designed because unless there is certain bridge or clue for the students to go through, they may not be motivated to do it. So, formulation of an activity needs to be based on the known concept to explore the unknown.

The sample lessons presented in this manual consist of different activities to be done by the students in groups or individually. Most of our schools' classes are so large that it is difficult to arrange seats and make groups for discussions. Besides this challenge, all the possible efforts should be made to involve students since lessons are successfully achieved when students' participation is maximized. For example it is possible to arrange discussion for students in a desk or face to face with other students across desks. .

Tasks that are given to the students should be clear and understandable so that students are not bothered with the procedures and steps of the activities. This can be done by providing worksheets in the form of tables or charts in which students are directed to write their responses. Provision of printed worksheets is not possible in most of our schools in such cases; the teacher may write the worksheet on the chalk board in advance or prepare it on manila papers and post on the wall where every student can see and copy.

As mentioned above, the lessons presented in this manual are only sample lessons selected as models for the remaining contents. Therefore the teachers may adapt the methods on the basis of their circumstances.

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- Describe the existence of small particles of substances
- Describe Dalton's atomic theory
- Comment on the postulates of Dalton's atomic theory

Materials: iron wool, iron filings, Paper clips

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The aim of the activity is to enable students understand how small the atom is and how scientists found its existence.

Make groups of students depending on your class situation. Let them discuss the following issues one after the other.

1. Is matter continuous or discrete? Meaning if you start cutting a piece of iron wool, is the process of cutting continuous or stops at a small particle that you cannot cut further?
2. Take a single particle of iron filings and try to divide it. Is it possible to do so? How would the particle of iron filings compared with the smallest possible iron?
3. How do you think scientists found the existence of the small particle of a substance?
4. When elements combine, their mass ratio is always in small whole number. Why do you think is this always true?

Let each of the group representatives make report on one of the issues. The other students should be given an opportunity to comment on the reports of the groups.

Since students have some idea regarding an atom from their primary school chemistry, they may come to a conclusion that matter is discrete. They may remember the ideas of the Greek philosophers, Aristotle and Democritus. However, you should be careful to avoid misconceptions such as 'particle of an iron filings is the smallest particle' because they cannot divide it further.

After they reflected their observation on the second question, you may give them the sizes of iron dust which is 4- 20µm (1m = 1,000,000 µm or 10^6 µm) and size of an atom of iron to be 156pm (1m = 1000000000000pm or 10^{12}pm). So, size of the atom of iron to its dust particle is 156pm/4x 10^6pm = 3.9×10^{-5} or 156pm/ 20x10^6pm = 7.8×10^6. This means one dust particle of iron should be broken into 39million to 7.8 million places to find an iron atom.

For the third question, students may suggest that scientists used microscopes to detect the atoms. It should be clear to the students that any instrument with the highest possible magnifying capacity cannot show the atom.

The fourth point is about the finding of Joseph Proust. Whatever idea the students forward, make clear that whole number ratio results only if the small particles of the combining substances unite in whole number; not in fractional parts. This can be explained by analogy. To make a bicycle, one bicycle body is assembled with two tyres. Half bicycle body and two tyres or one bicycle body and one and half tyre etc cannot make a bicycle. Similarly for example, two atoms of hydrogen and one atom of oxygen make one water molecule no more any less. So, whatever pure sample of water you take, it always contains 2:1 ratio of atoms of hydrogen and oxygen which makes 1:8 mass ratio.

With this explanation students understand that the existence of the small particle of a substance is confirmed by experimental processes.

Evaluation

Ask students whether matter is continuous or discrete and how is the existence of atoms proved.

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Introduce the postulates of Dalton's atomic theory. After making the ideas in the theory clear, allow them discuss each statement of the Dalton's atomic theory and determine whether they are still valid today.

1. Elements are made of small particles called atoms
2. Atoms are indivisible and can neither be created nor destroyed
3. All atoms of the same element are identical and have the same mass and size
4. Atoms of different elements have different masses and size
5. Atoms combine in small whole numbers to form compounds

Let their discussion focus on the following two points.

1. Are atoms indivisible particles as stated in postulate 2
2. Are all atoms of an element exactly identical in all respects including mass, postulate 3?

Let some students respond to the activity questions from their previous understanding of the atom. Much is not expected from them because the idea will be clear in the next lesson. However, you should make them curious about these two incorrect postulates by informing them about the findings of the experimental results. That atom is subdivided into electrons, protons and neutrons. Similarly, it is found that there are different atoms of the same element known as isotopes.

Evaluation

You can ask students to state the postulates of Dalton's atomic theory and to identify which of the postulates are not accepted at the present.

Concluding activity

Procedure

1. Show the students a chain of about 10 or more paper clips.
2. Ask them what would be the smallest possible particle if you separate the chain.
3. If you cut the last paper clip, can it play the role of a paper clip?

Let the students conclude that as the paper clip is the smallest particle of the chain, an atom is the smallest particle of an element.

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- Explain the discovery of electron
- Describe properties of electron

Materials

? Charts with discharge tubes

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Revision of the modern atomic theory

Let the student's state postulates of modern atomic theory focusing on its basic difference from Dalton's atomic theory. Make sure that slow learners have understood that atoms are divisible. This can be done by asking them to state and interpret the postulates. You may write the important point of the postulates they mention on the black board. Students should be invited to amend the ideas forwarded by their friends.

Evaluation:

- Which proposals in the Dalton's theory are modified in the modern atomic theory?
- What were the evidences that served as the basis for the amendments of Dalton's theory?

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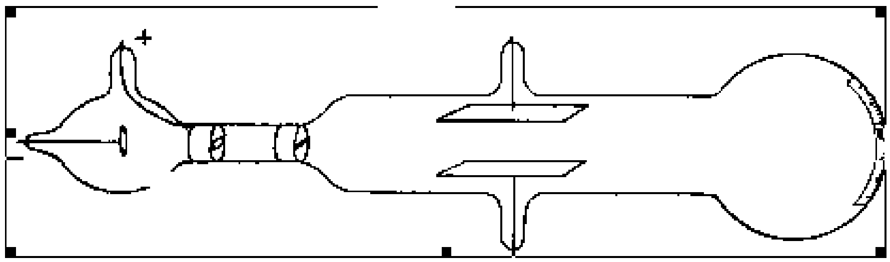
Ask students to **predict** how scientists came to know the presence of particles in an atom. Appreciate any idea they may forward. This may give you some information about students' preconception regarding atoms and their particles.

Then give a brief summary of the famous experiment carried out by Thomson using the discharge tube diagram. This could include the following points:

- The apparatus consisted of two electrodes in a tube from which most of the air had been removed



The Cathode Ray Tube or Discharge Tube

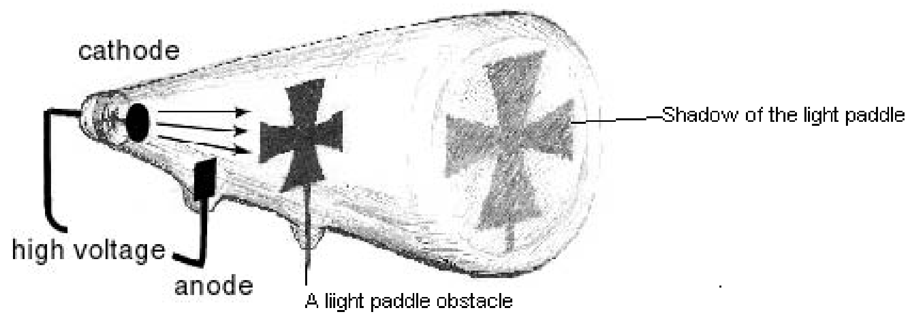
When a high potential difference was applied across the electrodes a stream of particles passed between them

- Thomson called these particles cathode rays because they came from the cathode
- The cathode rays moved straight to the anode, and through a hole in it, to a screen coated with zinc sulphide
- The zinc sulphide glowed when struck by the cathode rays
- The cathode rays were deflected by both magnetic and electrical fields
- The cathode rays were attracted by the +ve electric plate but repelled by the –ve electric plate
- Thomson obtained the same results when he changed the gas and the other materials in the tube
- A cathode ray consists of a stream of electrons

Make students into groups depending on your class size. You may give the following group activities. The activities may be written on a piece of paper in copies to distribute to groups or on a chart and posted on the wall for all students to see or on the chalk board.

Discuss the following and give reasons

1. Observe the experimental setup carefully; tell the parts of the apparatus and their functions.
2. When a light paddle was kept on the path of the cathode ray, the paddle was rotated. Tell the reason. An obstacle of a cross kept on the path of the ray casted a shadow on the screen of the discharge tube. Discuss why.



3. The rays are attracted to the positive terminal of the electric plate while repelled from the negative terminal. Why does this happen?
4. Thomson observed the same result when he used different gases and materials.

Generalize as in the following table

No	Observation	Findings
1	Rotation of light paddle	
2	Shadow casted on the screen	
3	Attraction of the ray to the positive terminal	
4	Observation of the same result for different gases	

Let the group representatives come in front to the chalk board and write their findings. The class should comment on the responses of each group.

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Ask students to state all the observations and explain their findings

Give the students opportunity to ask questions.

Let other students respond to the posed questions.

You may comment on the answer if necessary

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Ask some students randomly to give summary of the day’s lesson. Make sure that students are able to explain that:

- Cathode rays move in straight line because the obstacle on their path casts a shadow on the screen
- Cathode rays have masses because the paddle was rotated when it was strike by the ray.
- Cathode rays are negatively charged because they were attracted to the positive terminal of an electric field

- Cathode rays are contained in all substances because when different materials were used in the discharge tube, they showed the same result.

Students should discuss how, from this evidence, Thomson was able to state that:

- An electron carries a negative charge.
- An electron is a fundamental constituent of all matter

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- Tell the number of protons and electrons in an atom from the atomic number of the element
- Determine the number of neutrons from given values of atomic numbers and mass numbers
- Explain the atomic mass and isotope

Material

Work sheet

Note for the teacher

This lesson may take two or more periods. The first period should be used to introduce by giving starter activity and explaining the procedure of the activity. All the groups and the individual students should know their tasks during the activity. You should supervise the groups during their discussion and make clear any misunderstanding they may have. Students should be free to ask any question at any time and they should be encouraged to actively participate because they explain the tasks to their friends later on.

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You may start the lesson by the analogy of the assignment of roll number to the students in a classroom and its importance. Let them discuss how a roll number is given to a student and its importance. Guide them to come to the conclusion that roll number is assigned on the basis of alphabetical order of name of the students and teachers use them as short hands for the name of the students.

Now you can ask them how we identify different atoms of the same element and atoms of different elements using similar procedure.

Then introduce the lesson

Evaluation

You may ask them: can two or more students in a class have the same roll number?

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Procedure

- Group your students into a maximum of 8 students taking slow, medium and fast learners into consideration. This is a base group. Let the students in each base group elect their chair person and secretary.
- Give numbers 1 to 4 to the students in a group. This will be repeated in a group if the number of the students is more than 4. Meaning there may be two 1's and two 2's etc.
- Let all the 1's make one group, all the 2's the second group, the 3's third group and etc. These groups are called expert groups. They should also have a chair person.
- Assign each expert group a section of the textbook on atomic structure
    - Group 1- atomic number, textbook page 15
    - Group 2- mass number, textbook page 15-16
    - Group 3- atomic mass, textbook page 17-20
    - Group 4- isotopes, textbook page 17-20
- Provide a focus point of discussion on a chart or write it on a chalk board. The focus sheet will contain questions that help the students select key points/ideas from the reading. Points of discussion for each group are:

Atomic number group

1. What is an atomic number?
2. How is it related to the numbers of electrons and protons in an atom?
3. What is the purpose of an atomic number?
4. Can two or more different atoms have the same atomic numbers?
5. How is an atomic number used in the periodic table?

Mass number group

1. What is mass number?
2. How do you determine it from the number of nuclear particles?
3. Is mass number the same for all atoms of the same element? why?
4. What is the relationship between the number of the protons, the number of neutrons and the mass number?
5. How do we use mass number to identify a particular atom of an element?

Isotope group

1. What is an isotope?
2. What is the difference between isotopes of the same element?
3. Give examples of elements with isotopes.
4. Represent isotopes of the same element using symbolic representation

Atomic mass group

1. How do you compare the actual mass of an atom to the mass of objects in your environment?
2. Is it possible to measure mass of an atom using ordinary scale?
3. What did the scientists do to avoid the difficulty of using the extremely small mass of the atoms?
4. What is relative atomic mass?
5. What is the standard element in the establishment of relative atomic mass? Which element is used for this purpose?
6. What is the unit of relative atomic mass? How is it determined?
7. What is the average atomic mass?
8. How is the average atomic mass determined?
9. Calculate the average atomic mass of element X. It has two isotopes X-40 and X-41 with relative abundance of 60% and 40% respectively.

- Instruct each group to read their section of the textbook and answer the questions on the focus sheet.
- Students in the expert groups will discuss the reading and come to an agreement on the key points of the text. Students will revise the answers on their focus sheets, if necessary.
- Instruct students to return to their base groups and take turns to share the key points from their section of the text. Students will answer the questions on the focus sheet as their group members discuss the key points.

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Let the base group representatives report the key points of their discussion to the whole class. You may ask them the main key points of each topic.

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Let the students perform the following activities.

1. Given numbers of protons, neutrons and electrons, let them write symbolic representation of the element as $^{A}_{Z}X$.
2. Give number of protons, number of neutrons or mass number, let them calculate the other.
3. Let them define relative atomic mass and average atomic mass.
4. Given relative abundance and isotopic masses let them calculate average atomic masses.

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- Explain what a model is
- Name the five atomic models
- Explain the procedures of researching works Dalton, Thomson, Rutherford and Bohr did in attempting to describe atomic structure.

Materials

Worksheet

The lesson may be started by initiating discussion on a model. Ask students what they know about a model. The questions can be

- What is a model?
- Why do we use models?
- Tell anything you know that is represented by a model.
- Why did scientists use models to describe atoms?

Give some time for the students to think over. Then let students give their opinions. You may facilitate discussion on the different views forwarded by the students.

Students may forward ideas like:

- Models are ways of representing some thing
- Their model examination of grade 8, models they used in their biology classes,
- Scientists want to teach the others etc.

Whatever idea they mentioned, do not forget to praise them and paraphrase their points in the correct direction.

After the discussion make sure that they arrive at the following conclusions:

- A Model is the mind's picture of what a real thing would look like. From idea and experiences the mind constructs picture of models about things which cannot be easily seen directly.
- We use models if we cannot access the actual object directly due to different reasons. These may be
    - Objects that are too big, too small or positioned so it is difficult for them to be seen easily. E.g. cell, heart, atom
    - Processes that cannot easily be seen directly. E.g. digestion
    - Abstract ideas. E.g. particle nature of substances, energy transfer etc

- In biology internal organs taught by models. This include: the skeletal system, digestive system, the heart etc. In chemistry also abstract concepts like atoms and molecules are described by models.
- Atoms are extremely small invisible particles. Scientists study their behaviour using experimental investigations. To explain the behaviour of the atoms, they use models.

Remind the students the works of Dalton, Thomson, Rutherford and Bohr and ask them how their contribution can be depicted.

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Ask them to explain what models are and why we use them.

Students will explore the development of atomic models. They will learn about the atom, how the concept of the atom has changed over time and how this illustrates several aspects of the nature of science. This means they understand how development of the knowledge of the atomic structure increases the fields of study in science.

They will research and answer questions in relation to the development of the atomic models by each of the following scientists. Students will be expected to present biography of one of the scientists to their classmates.

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Procedure

1. Let your student's call numbers 1-4 one after the other.
2. Give Dalton's theory for those who called the number 1, Thomson's theory for those who called the number 2, and Rutherford's theory for those who called the number 3 and Bohr's models for those who called the number 4.
3. Write the following assignment guiding points on the chalk board so that all students copy and use them in their investigations.

Dalton's group

a. When Dalton did propose his theory?
b. What was his nationality?
c. What was his work?
d. Did he conduct experiments to develop his model?
e. What was the basis of his theory?
f. How did his model of the atom change the understanding of matter people had by that time?
g. Draw and describe his model of the atom?

Rutherford's group

a. When did Rutherford formulate his model of the atom?
b. What was his nationality?
c. What was the name of his experimental apparatus?
d. Give the summary of his experiments that lead him to propose his model
e. What was his contribution to the development of the atomic theory?
f. How did he amend Thomson's atomic model?
g. Draw and describe his model of the atom

Bohr's Group

a. When did Bohr formulate his model of the atom?
b. What was his nationality?
c. What was the name of his experimental apparatus?
d. Give the summary of his experiments that lead him to propose his model
e. What was his contribution to the development of the atomic theory?
f. Write down his statements about the electron in an atom.
g. How did he amend Rutherford's atomic model?
h. Draw and describe his model of the atom

Members of each group should come up with a resolution to the posed questions. Then after completion of the task tell them to go to their respective base groups to share their findings to their friends.

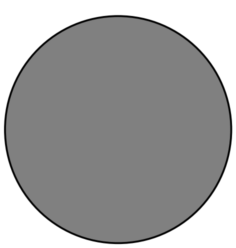
Evaluation

Let representatives of each base group present the main points of their discussion.

You may ask them the key points of each atomic model.

Concluding activity

Let students summarize the development of atomic model starting from Dalton's theory to the Bohr's model.



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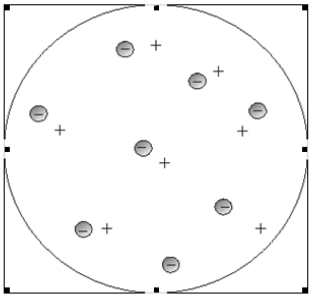

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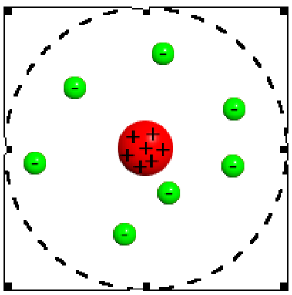

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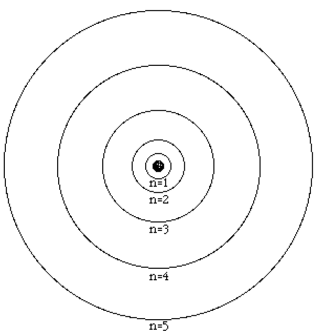

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- Describe the quantum mechanical model
- Describe the main energy levels and sub-energy levels

Material:

1. chart showing main energy level, sub-energy level, and maximum electron capacity (table 1.5 on page 27 of student textbook)
2. chart for sub-shell, number of orbital and maximum number of electrons

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You can start the lesson by revising Bohr's electron configuration of main energy levels. Ask students:

- How are electrons arranged in an atom?
- What do we call the stable orbits in which electrons exist?
- What are the names of different energy levels?
- What are the maximum electron capacities of the energy levels? How do you determine the maximum number of electrons that can be accommodated by a given energy level?
- Give them some time after each question so that they share idea with their partners. Let them raise hands and respond. Write the core idea of the students' answers on the chalk board. Allow the other students to comment the answers and correct if necessary. . This will give you the opportunity to assess students understanding vis avis the most recent lessons. Don't forget encouraging slow learners to involve during such revision discussions.

Obviously students can answer most of the questions because they learned it in their grade 7 as well as in the previous lesson.

However, make sure that all students come to the consensus that according to Bohr:

- Electrons in an atom are arranged in restricted number of stable orbits or energy levels in which they neither absorb nor emit energy.
- The orbits are called energy levels or shell
- The energy levels are denoted by K, L, M, N....shells or by principal quantum number 1, 2, 3, 4....energy levels
- The energy levels can accommodate maximum of 2, 8, 18, 32 electrons respectively. The maximum electron capacity of an energy level is calculated by $2n^2$ where n is principal quantum number.

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Give them elements with atomic numbers of 11, 15 and 18 and ask them to write Bohr's diagrammatic representation of the atoms.

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You can use the following analogy to explain the quantum mechanical model. As you have residence address electrons in an atom also have systematic locations. As you can locate your address starting from Kebele to the bed on which you sleep, it is possible to determine position of an electron starting from atom to the volume of space it occupies.

Your address	**Analogous location of an electron**
Kebele	Atom
Home	Main energy level
Room in a home	Sub- energy level in a main energy level
Bed in a room	Orbital in sub-energy level
Direction of sleeping in a bed	Spin of an electron in an orbital

Now you can make students discuss with their partners by raising some questions.

- Are all the kebeles equal in land size or in number of residents? How about the atoms?
- How many houses are there in a kebele? Different or the same? Can you tell number of shells in an atom?
- Do all houses have the same number of rooms? What about the number of sub-energy level in the energy levels?
- You may explain what a sub-shell is at this point. Those main energy levels are sub divided in to sub energy levels. There are four types of sub-energy levels called the s, p, d and f.
- How about the number of beds in a room? Is it analogous to the number of orbitals in a sub-shell?
- Orbital should also be introduced here. It is a volume of space occupied by maximum of 2 electrons.
- The maximum number of people sleeping on a bed under normal condition? Maximum electron capacity of an orbital?
- Students should be informed that the two electrons in an orbital spin in opposite direction.

Then use the chart to harmonize the discussion. As kebeles have different size so do the atoms. Small atoms have lower number of shells as small kebeles have lower number of houses.

Similarly, as houses of many family members, should have normally many rooms or sleeping places, shells or main energy levels of many electrons have many sub-shells or sub-energy levels as well.

Indeed as large rooms accommodate many beds and many people, larger sub-shells have many orbitals and hold many electrons.

Usually two persons (male and female) sleep in a bed. Orbitals are also safe heavens for two electrons but can never hold more than two electrons. You may tell them humorously that when two persons sleep in a narrow bed, they sleep in opposite direction so that they can fit to the bed. Similarly, electrons always orient in opposite spin in an orbital.

Use the second chart to explain the sub-shell, number of orbitals and their maximum capacity.

Sub-shell/sub-energy level	**Number of orbitals**	**Maximum number of electrons**
s	1	2
p	3	6
d	5	10
f	7	14

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You may give them the following individual work.

1. Write down the first four main energy levels and their respective sub- energy levels
2. Write down the sub-energy levels and their respective number of orbitals.
3. What is the maximum number of electrons in each of the four sub energy levels?

You may observe the works of each student and assist those who have difficulties.

Give opportunity for the students to ask questions. Let other students answer the forwarded questions.

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Explain how the quantum mechanical model modified the Bohr model?

Make sure that the slow learners are included in the lesson. Let them respond to this question as follows:

- The main energy levels have sub-energy levels.
- The sub-energy levels consist of a number of orbitals that increases as quantum number increases
- The orbital can accommodate a maximum of two electrons
- The two electrons in an orbital are oriented in opposite spin.

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- State the modern periodic law
- Describe periods
- Describe group
- Describe the relationship between the electronic configuration and the structure of the modern periodic table

Materials:

- Bohr model of the atoms of atomic number 1-18 drawn on a hard paper and carefully cut out. The number of models must be equal to the number of groups of students. Name and symbol of the elements should not be written on the model.
- Manila paper for each group, Gum

You can print and carefully cut the figures of the models given at the back of the manual.

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Imagine that students of grades 1-8 in a primary school are lined up straight by a sport teacher during a flag ceremony. Supposing that each grade has only one section, ask students to discuss the following in their groups

1. How are the students in the vertical and students in the horizontal rows related?
2. Does it resemble the Mendeleev's periodic table?
3. Explain the drawback in the periodicity of the students' arrangement?

Let them discuss the relationship between the vertical and the horizontal lines.

Gear students' discussion to make the following conclusion:

- All the shortest students of the classes are in the first raw and the second most short students are in the second raw etc.
- The grade of the students in a raw consecutively increases by one from 1 to 8
- The height of the students in a vertical column is also increasing gradually.
- The students in a vertical raw are in the same grade.

Although there are certain similarities in the rows as well as in the columns, the weight of students along the horizontal rows may not show some regularity. Analogously, this may be compared with the Mendeleev's classification which was based on atomic masses.

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With respect to periodicity, ask the students to find out the anomalies of the Mendeleev's periodic table and that of the arrangement of students in a line during the flag ceremony.

Students should mention there is irregularity in the weight of students along the horizontal rows. This is the same as the irregularity in Mendeleev's table which was based on atomic masses. There is irregularity in properties because an element of large mass has been arranged in a row before an element of a small mass

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Procedure

- Arrange students into groups equal to the number of sets of models you prepared
- Provide each group with the models
- Order the students to sort and arrange the models with certain types of similarities into horizontal row and vertical column.
- Remind them that their table should come up with periodicity
- If you observe them facing difficulty during your supervision, give them clue to remember electron configuration of the elements.
- Let them paste the models on the manila with the gum
- In their discussion, they should give reason for their arrangement
- What criteria they used to arrange elements in horizontal rows?
- What criteria they used to arrange elements in vertical columns?
- What generalization can be drawn regarding the classification of the elements?
- The group representative should come in front to present the groups work
- Let the rest of the class comment and discuss the tables presented

Dear teacher, students might have good back ground knowledge of the periodic classification from their grade 7 chemistry and they might come up with correct conclusion. Make sure that they managed the following points

- All elements in a horizontal row have the same number of shells and the horizontal rows are called periods
- Number of shells of atoms of the elements equals the period number of the element in the periodic table
- All elements in the vertical columns have the same number of valence electrons and vertical columns are called groups
- Number of valence electrons of atoms of the elements equals the group number of the element in the periodic table

Periodic properties of the elements are the function of their atomic numbers.

Their table should look like the following but in Bohr's model.

H							He
Li	Be	B	C	N	O	F	Ne
Na	Mg	Al	Si	P	S	Cl	Ar
K	Ca						

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Ask the students the following questions

- What do elements in the same horizontal rows have in common?
- What do elements in the same vertical columns have in common?
- Are they arranged according to the increasing order of their masses as in Mendeleev's table or according to the variation of another important factor?
- State a periodic law based on your observation.

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You can use the long form of the periodic table to conclude the lesson. Display the periodic table so that all students can see it.

Let them closely look at the table to compare their works of arranging the elements.

You may give them the following individual activities so that they can come up with generalization.

Complete the following tables.

1. Find the valence numbers by writing electron configuration of at least one element from each group.

Group number	1	2	3	4	5	6	7	8
Number of valence electrons								

2. Find the numbers of shells by writing electron configuration of at least one element from each period.

Period number	1	2	3	4	5	6	7
Number of shells or energy levels							

Check the performance of student and help the slow learners to come to the conclusion**.**

Students may do the activities as follows:

1. Finding valence number

They may write electron configuration of any one of the group IA elements. For example:

$_{11}$ Na – electron configuration for the sub- energy levels is: $1s^2\ 2s^2 2p^6 3s^1$. The last energy level, the L-shell contains only 1 electron. Therefore, the number of valence electron for group IA is 1.

Group IIA: $_{20}$Ca can be taken as an example, which has electron configuration of

$1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 4s^2$. The last energy level of calcium, the fourth energy level, contains 2 electrons. Therefore the number of valence electrons of group IIA elements is 2. The number of valence electrons of the other groups can also be found in the same way.

2. Finding Numbers of shells or energy levels

The number of shells of an element is also determined by writing its electron configuration. The number of shells or energy level of an element is the number of shells its electrons occupy. Any one element of a period can be taken as an example. $_{15}$P can be taken from period 3, which has electron configuration of $1s^2\ 2s^2 2p^6 3s^2 3p^3$. Since electrons of phosphorus occupy 3 energy levels, it has 3 shells. Similarly $_{31}$Ga can be taken from period 4. Gallium has an electron configuration of $1s^2\ 2s^2 2p^6 3s^2 3p^6 4s^2 3d^{10} 4p^1$, as the result, its number of shells is 4. In this way students can complete the tables and make conclusions that the number of valence electrons is equal to the group number of the element in the periodic table. Similarly the number of shells of an element is equal to the number of period of the periodic table in which it is found.

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What is the difference between Mendeleev's periodic law and the modern periodic law?

Give examples from the periodic table to show that Mendeleev's classification, which was based on atomic mass, has short comings.

What do we call the horizontal rows? What is the common characteristic of the elements in rows?

What do we call the vertical columns? How are the elements in the columns related?

Make sure that the slow learners correctly respond to the above questions. These are:

Mendeleev's periodic law is based on atomic mass while the modern periodic law is based on the atomic number. One of the students should come to the periodic table to show the mass order of K and Ar. The others may tell that many elements have isotopes with different masses. Atoms of the same elements cannot have different positions in the periodic table.

The horizontal rows are called periods and they contain elements with the same number of electron shells. The vertical columns are called groups and elements in a group are related because they have the same number of valence electrons. Encourage the fast learner students to work out electron configurations of the heavy elements and find their period and group numbers in the periodic table.

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- Describe the three classes of the elements in the modern Periodic Table
- Describe the four blocks of the elements in the periodic table in relation to their electronic configuration
- Tell the block of an element from its electronic configuration

Materials

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This lesson can be started by revising the relationship between electron configuration and the periodic classification of the elements.

Provide students an activity to find the group and period numbers of the elements with atomic numbers: 6, 15 and 19.

Let a few students come forward to write the electron configuration of one element on a chalk board and assign the group and period numbers. The remaining students should give comments on the works.

At this level students should write the electron configurations both in main energy levels and sub-energy levels

Atomic number 6: - 2, 4 or $1s^2 2s^2 2p^2$ because this element has two main energy levels, it is located in period 2. Similarly, it has 4 electrons in the outer most shell, L-shell (2s and 2p), it is located in group 4 of the periodic table.

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Students can be asked how one can find out the period and group numbers of an element.

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Procedure

1. Arrange students in groups depending on the class size.
2. Let each group elect chair man and secretary

   The following activity may be printed and given for each group or can be written on the chalk board before hand.

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3. Give them the following four groups of hypothetical elements with atomic numbers. ${}_{11}A$,

a) ${}_{38}B$, ${}_{4}C$, ${}_{19}D$
b) ${}_{8}E$, ${}_{13}F$, ${}_{35}G$, ${}_{5}H$
c) ${}_{24}I$, ${}_{40}J$, ${}_{30}K$, ${}_{21}L$
d) ${}_{58}M$, ${}_{90}Q$, ${}_{64}R$, ${}_{66}T$

4. Write the electron configuration of each member and answer the following questions in group.

a. What is the similarity in electron configuration among members of each group?
b. Write valence electrons configuration of each group of the elements.
c. In which of the group(s) do all members (elements) have valence electrons in the same energy level?
d. In which of the group(s) do members have valence electrons in different energy levels?
e. Write the relative position of the elements each group in the periodic table. This can be done by observing the periodic table.

- Group a.
- Group b.
- Group c.
- Group d.

f. Give your own reason why these groups of elements are given the positions in the periodic table.
g. Write down a summary or generalization about the classification of the elements in the periodic table.
h. Let the representative of each group present their observations to the class.

The whole class may discuss on the presentations, questions answers among students should be encouraged.

On the basis of students' discussion, you can give the following explanations

- Those elements whose valence electrons fall in the s-orbital are called s-block elements. Ask them in which group they are?
- Elements with valence electrons in the p-orbital are called p-block elements. Ask them which group elements they are?
- The **s** and **p** block elements are collectively called representative elements or main group elements. The groups are represented by roman numbers followed by letter **A.** These are groups IA to VIIA
- Elements whose valence electrons enter the d- orbital are called d-block and those with the last electron in f-orbital are f-block.
- The d-blocks are called transition elements because they are located between the two representative groups of elements.
- The f-block elements are called the rare earth metals because they are found rarely in nature.
- You may give further explanation on each block of the elements the next period.

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Students can be asked the following oral questions to answer individually.

1. How many blocks does the modern periodic table have?
2. What is the basis to classify elements in the periodic table into blocks?
3. Identify the relative positions of each block in the periodic table.
4. What are the especial names of each group?

Encourage the slow learners to answer the above questions.

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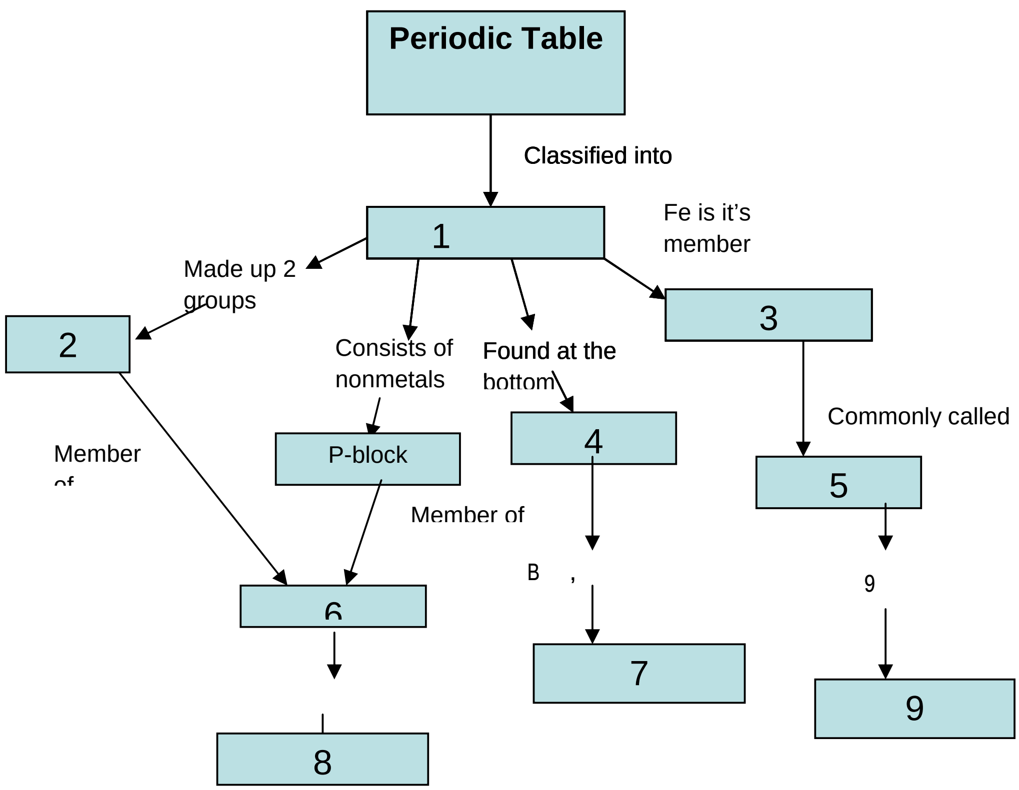
You can give the following concept map for the students as a concluding activity.

Fill the blank spaces in the concept map with the appropriate terms.



Make sure that students copied and completed the concept map successfully as follows.

1. Block
2. s-block
3. d-block
4. f- block
5. Transition elements
6. Representative elements
7. Rare earth metals
8. Main group elements
9. Middle

Additional exercise

The following is part of a periodic table. Carefully observe the table and answer the questions below.

Group	**IA**	**IIA**	**IIIA**	**IB**	**IVB**	**IVA**	**VA**	**VIA**	**VIIA**	**VIIIA**
Period										
1	A									
2			B						E	C
3										
4				F	D					

1. Identify the letter (s) which represents the s-block elements.
2. Identify the letter (s) which represents a noble gas.
3. Identify the letter(s) which represent a halogen.
4. Where would you place an element 'g' with electronic configuration of 2,8,4 in the given table?
5. How many valence electrons has the element denoted by b?
6. What is the valence number of the element represented by c?
7. Identify the element with the highest metallic character
8. How many shells has the element represented by 'd'?
9. What is the similarity between the electronic configurations of the elements represented by 'b', 'e' and 'c'?
10. Identify the element(s) which has the last electron in d-orbital

Answer

1. A
2. C
3. E
4. Group IVA and period 3
5. 3
6. 8
7. A
8. 3
9. They have the same shells.
10. D and F

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- Explain the general trends in properties of elements down a group of the Periodic Table
- Explain the general trends in properties of elements across a period of the Periodic Table
- Deduce the properties of an element from its position in the Periodic Table
- Make a charts to show the trends in properties of elements in the Periodic Table

Materials

Periodic table, charts to show trends of properties of the elements in the periodic table, worksheet and concept map.

Note for the teacher

This sub-topic is covered in six periods. So, you may use the first period to group students, explain the procedures of the activities, sharing the tasks and checking whether students understood the process clearly.

You may assign two groups to present two properties in a period. Each group may be given 10minutes to present its work. The two groups together need 20minutes. 10 minutes can be used for questions and answers. The remaining 10 minutes may be used for evaluation. The last day may be used for summary, questions and answers.

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Revising period and group of the periodic table

The following points may be raised for discussion in pairs with their bench mates and respond afterwards.

- What are the relationships between elements in a period?
- How are elements in a group of the periodic table related?
- Do all elements in the same period have the same properties?
- Do all elements in the same group have the same properties?
- Tell the properties in the period or group you know and their trends.

Pose for some time so that students discuss and let them give their response. Encourage the rest of the class to supplement, amend, object or approve the answers given by a group representative.

Some students may think that all elements in a group are identical in all respects. But you should explain that although elements in a group have the same valence electrons, they have different properties. At this stage introduce properties like: nuclear charge, atomic size, electron affinity, electro negativity, ionization energy and metallic properties.

Students may know some of these properties and their trends in a period and group. After they adequately discussed, check that all of them can give the following summary points:

- All elements in a period have the same number of shells and those in the same group have the same number of valence electrons.
- However, their physical and chemical properties vary in a period and a group with certain trends that they can explain after they study this lesson.
- The periodic properties are: nuclear charge, atomic size, electron affinity, electro negativity, ionization energy and metallic character.

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Give them the following evaluation questions: What happens to properties of the elements as you move in a period and a group? List properties of the elements which show some changes across a period and a group of the periodic table.

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Procedure

1. Arrange your students into base groups of 6 members randomly. Give numbers 1 to 6 to the students in each base group. Giving number should be carefully done so that if number 1 in group 1 is fast learner, number 2 in group 2 should be fast learner etc. so that in the expert group distribution of students include all kinds of learners.
2. Let all the number 1's come together to make one group, all the number 2's make the second group and all the number 3's the third group etc. These groups are called expert groups.
3. Arrange the expert groups according to the following correspondence :

    - Group 1 .... nuclear charge
    - Group 2 .... atomic size
    - Group 3 .... ionization energy
    - Group 4 .... electro negativity
    - Group 5 .... electro negativity
    - Group 6 .... metallic properties

4. Provide worksheet to each group that contains discussion points. If facilities are not available to supply written worksheet, it is possible to write the points on the chalk board before hand.

    Discussion points

    a. Nuclear charge

    1. What is nuclear charge?
    2. How the trend does vary along a period? Why?
    3. How the trend does vary in a group? Why?
    4. Give examples by taking one period and one group of the periodic table.

5. Draw a graph of nuclear charge against group number and a graph of nuclear charge against period number. Compare the two graphs and write down your observation.
6. What is effective nuclear charge?
7. Explain trends of the nuclear charge in a period and in a group of the periodic table. Give reasons.

b. **Atomic size/ atomic radius**

1. What is atomic size?
2. How the trend does vary along a period? Why?
3. What are the factors affecting it along a period?
4. How the trend does vary in a group? Why?
5. What factors influence atomic size when descending down a group?
6. Give example by taking one period and one group of the periodic table. Draw Bohr's model to explain how atomic size changes along the period and down the group.
7. Where in the periodic table is the largest atom located? What about the smallest atom?

c. Ionization energy

1. What is ionization energy?
2. Give three examples of the ionization of atoms
3. How is its trend along the period? Why?
4. What factors influence its trend in the period of the periodic table? Explain the effects of each factor.
5. How is its trend in the group? Why?
6. What factors influence its trend in the group of the periodic table? Explain the effects of each factor.
7. Where in the periodic table is the atom with the largest ionization energy located? What about the atom with the smallest ionization energy?
8. Do the metals or the non-metals have the highest ionization energy? Why?

d. Electron affinity

1. What is electron affinity?
2. Give three examples of reactions to show electron affinity.
3. How is its trend along the period? Why?
4. What factors influence its trend in the period of the periodic table? Explain the effects of each factor.
5. How is its trend in the group? Why?
6. What factors influence its trend in the group of the periodic table? Explain the effects of each factor.
7. Where in the periodic table is the atom with the largest electron affinity located? What about the atom with the smallest electron affinity?
8. Do the metals or the non-metals have the highest electron affinity? Why?

e. Electro negativity

1. What is electro negativity?
2. How is its trend along the period? Why?
3. What factors influence its trend in the period of the periodic table? Explain the effects of each factor.
4. How is its trend in the group? Why?
5. What factors influence its trend in the group of the periodic table? Explain the effects of each factor.
6. Where in the periodic table is the atom with the largest electro negativity located? What about the atom with the smallest electro negativity?
7. Do the metals or the non-metals have the highest electro negativity? Why?

f. Metallic character

1. What is Metallic character?
2. How is its trend along the period? Why?
3. What factors influence its trend in the period of the periodic table? Explain the effects of each factor.
4. How is its trend in the group? Why?
5. What factors influence its trend in the group of the periodic table? Explain the effects of each factor.
6. Where in the periodic table are the metals located? How about the non-metals?
7. Where do we find the most metallic element? What about the least metallic element?

5. Let the students take note of the group's discussion, and go back to their base group.
6. In the base group each expert presents and explains his/her topics points to the groups.
7. The members listen to the explanations, ask and answer questions.

You should supervise discussions of the students and avoid any misconceptions they that may result. Some slow learners may encounter difficulty to explain their topics successfully. In such cases it is advisable to assist and encourage by giving some clues.

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You can give the following kinds of class work exercises after the lesson so that students can do individually. This gives you the opportunity to know individual student's performance. Check the works of the students by giving more emphasis to the slow learners. The fast learners should also be challenged by giving additional works depending on the lesson topics.

Here are some sample questions. The first one constitutes effective nuclear charge, atomic size and ionization energy while the second one summarizes the whole lessons on periodic properties. You can construct similar questions and other alternative assessment to evaluate your students. It is believed that such tabular forms of assessment somewhat motivates students by creating some interest. So, the teacher should be creative enough to formulate such questions. However, students may face difficulty in understanding it. To avoid misunderstanding of learners, give them clear and adequate directions.

1. The following table shows part of a periodic table. Let students answer the following questions related to the table.

Period	Group									
	IA	IIA	IB	IIB	IIIA	IVA	VA	VIA	VIIA	VIIIA
2	Li	Be			B	C	N	O	F	Ne
3	Na	Mg			Al	Si	P	S	Cl	Ar
4	K	Ca	Sc	Ti	Ga	Ge	As	Se	Br	Kr

Fill in the blank space with the correct term or phrase based on the above table.

1. The element with the list nuclear charge is (1) _______ and the one with the highest nuclear charge (2) _______ Nuclear charge of S is (3) _______than nuclear charge of Se.

   As you go from Na to Cl along the period nuclear charge (4) _______.

   Effective nuclear charge (5) _______ from B to Ga while it (6) _______ from Na to Ar.

   Shielding or screening effect (7) _______down the group but (8)_______ along the period from left to right.

   Atomic size of Li is (9) _______ than that of K.

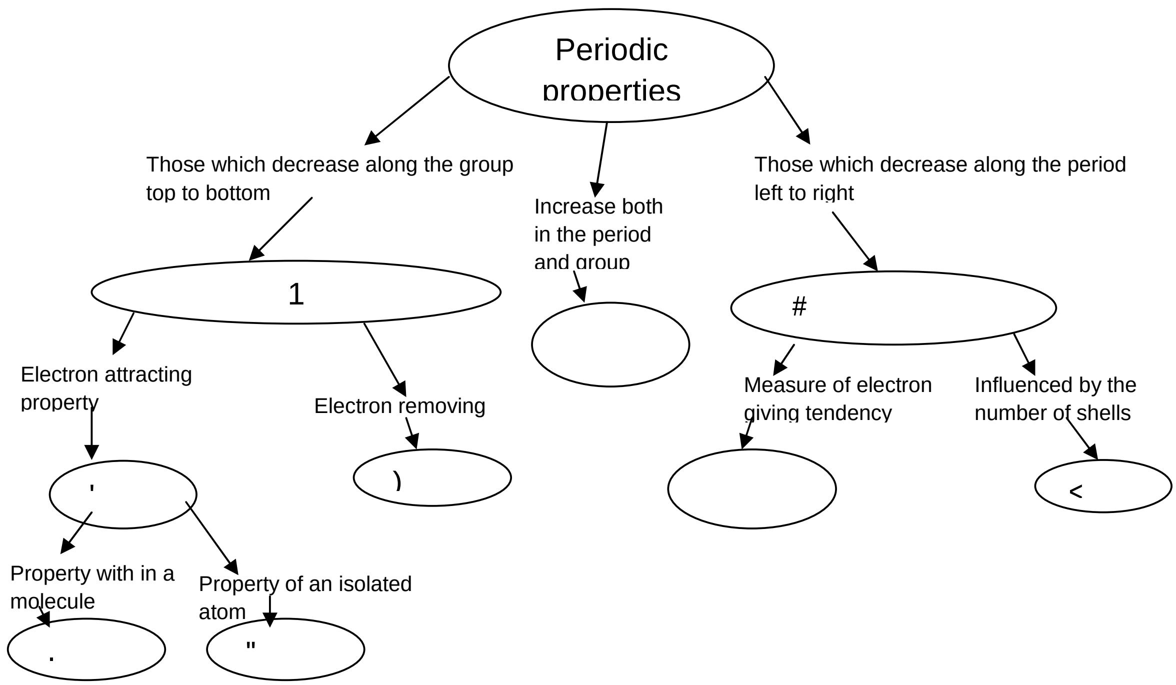
   Element with the least atomic size is (10) _______

   Element with highest atomic size is (11) _______

   Atomic size of Ca is (12) _______ than atomic size of be because number of (13) _______ increases down the group.

   Atomic size (14) _______ from K to Kr because electrons are filled on the same shell, the (15) _______ continuously increase and attraction force increases.

2. Complete the following concept map using: ionization energy, atomic size, electron affinity, electro negativity and metallic character.



Answer 1:

1. Li
2. Kr
3. Less
4. Remains the same
5. Increases
6. Increases
7. Increases
8. Remains the same
9. Smaller
10. Ne
11. K
12. Larger
13. Energy levels
14. Decrease
15. Nuclear charge

Answer 2:

1. Ionization energy, electron affinity, electro negativity
2. Nuclear charge
3. Atomic size, metallic character
4. Electro negativity, electron affinity
5. Ionization energy
6. Metallic Character
7. Atomic size
8. Electron negativity
9. Electron affinity

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Let students come to the chalk board and explain the trends of the periodic properties by using diagrams arrows and other descriptions possible. In this way 12 students can gat opportunity to explain one property each either across a period or along a group. The rest of the class should also be involved by giving corrections if there are mistakes or give approvals for the correct works.

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To enable the students to:

- Describe the advantages of the periodic classification of the elements in the study of chemistry.
- Appreciate the classification of elements done by different scientists.
- Describe the most important features of each classification.
- Discuss the changes in methods of classification with time.

Materials

Periodic table chart

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Let the students revise the previous lessons on periodic table by raising all the contents from early attempts of classification to the trends in properties of the elements. This can be done by asking leading questions like:

- What were the historical attempts of classification of the elements? What are their similarities?
- How does the Mendeleev's classification differ from the other earlier classifications?
- What are the differences between the Mendeleev's and the modern periodic laws?
- How many blocks does the modern periodic table have? What is the basis for these blocks?
- How many groups and periods are there in the modern periodic table? What are the specific features of each period and group?
- How do you determine the period and the group numbers of an element if its atomic number is given?
- How is the electronic configuration of atom of an element related to its location in the periodic table?
- Which properties of the elements change in the period of the periodic table? How and why?
- Which properties of the elements change in the group of the periodic table? How and why?

Make sure that all students have participated in the revision discussion and have grasped the concepts.

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Give atomic numbers of some elements and ask them to

- Determine period and group numbers.
- Number of shells and valence electrons

- Decide whether they are metals or non-metals
- Predict their properties like ionization energy, electron affinity etc.

Now you can provide the following project work.

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1. You may write the procedure on the chalk board. Let the students understand it clearly and submit their work in a week time.
2. You may provide lists of reference books available in the library
3. The Students may be asked to collect the information and prepare a written report of the project using the format given below

Objectives of the Project- why they are doing the project.
Introduction – some information about their works.
Material required (if any) – this may be any material they used during their project work.
Procedure – stapes they followed in their work.
Presentation of the Information / Data Collected.
Conclusion.
Reference used

Collect the students work, check and categorize in to three: the best, medium and poor performance (you may do it based on your convenience). You may allow one student from each category to present the group work for five minutes.

When you analyze the project and the presentation, you may encounter the following conditions.

A few students may have not been able to collect information from different sources or may have written the whole content from the text book; or students may have been motivated to search material from different sources.

A Few students may have not been able to analyze the data collected and understand the merits and demerits of different classification of elements. So, you may help the students understand the significance of classifying the element in periods and groups.

After the completion of the project, you may give the detailed information about the periodic classification of elements, involving them in the lesson, using question and answer techniques.

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- Define chemical bonding
- Explain why atoms form chemical bonds

Note for the teacher

Chemical bonding is one of the basic topics in chemistry. Since it is an abstract concept which cannot be applied to everyday life directly, many students aren't able to comprehend this concept. They may have difficulty to relate a microscopic world to macroscopic world.

In addition, understanding chemical bonding requires some concepts from physics such as energy and force in which students already have difficulties in understanding. As a result, they hold many misconceptions related to chemical bonding. Understanding chemical bonding is important in chemistry in order to comprehend the nature of the chemical reactions and some physical properties such as boiling point. Students usually have difficulties in understanding why and how bonding occurs.

Materials:

Chart for Lewis structures of the elements, periodic table chart

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Observing our environment

Let students observe their surroundings and identify substances they see. Ask them to tell whether most of the substances are compounds, mixtures or elements. The materials they listed may be:

Chalk board, chalk, the wall, the floor, air, pen, pencil, book, exercise book, desk, and wood, iron materials covered with paints, cloths and pupils.

1. Are most of the materials elements, compounds or mixtures?
2. How many of these materials are elements?
3. Why do we find many elements in our surroundings in a combined form?
4. Why some elements are found un combined in nature?

Let students give any idea they have. You may jot down the different ideas forwarded by the students. At this stage no correct information is expected from the students. The different guesses forwarded will help you to know students' perception of a chemical bond.

Now lead students to come to the conclusion, that among the listed substances, the elements are oxygen, nitrogen, and some noble gases like argon and helium, in the mixture of air, and iron materials covered by certain enamel (galvanized or painted). The elements oxygen and nitrogen are found as combined forming oxygen and nitrogen molecules respectively. As the result they are found as free molecules. However, iron is covered not to combine with other elements (remind them about rusting of iron). So, the only elements found as free atoms are the noble gases.

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Ask the students about all the elements in the periodic table. Let them identify which ones are found as free atoms in nature?

Main activity (28 minutes)

1. Why is the noble gas elements not combined?

Let the students make a research on the structure of these elements in comparison to the other elements. The following activity can help to make the investigation.

1. Give the following atomic numbers of the elements: 1, 2, 11, 13, 6, 10, 15, 17, 18, 7 and 36
2. Write down electron configuration in the main energy levels
3. Identify those elements with similar electron configuration. What makes them similar?
4. Where do you find the elements with similar configuration in the periodic table?
5. Why do not these elements combine?
6. What influences the reactivity of elements?

Check the students' work and assist those with difficulty. They may identify elements with only 8 electrons in the outer shells are similar elements. But they may fail to categorize He as one member of the group. Explain that He is the member of noble gases because it has a complete first shell.

After some 10 minutes, ask the students to explain their findings.

Students should distinguish between noble and non-noble gases as follows

Elements with incomplete outer shell	**Elements with complete outer shell**
H: 1	He: 2
C: 2,4	Ne: 2,8
N:2,5	Ar: 2,8,8
Na: 2,8,1	Kr: 2,8,18,8
Al: 2,8,3	
P: 2,8,5	
Cl: 2,8,7	

The difference between the two categories of elements is that those in the first category have 1 to 7 outer most electrons or incomplete shells where as elements in the second category have complete outer shells.

They should refer to the periodic table to find out that the elements with complete outer shells are found at the end of each period of the periodic table, or the right most group VIIIA.

They should also come to the conclusion that these elements do not combine because they have complete electron configuration. They can explain that electronic structure influences the combining capacity of the elements.

Help students to know that not only have noble gases complete outer shells but also lower energies.

Now students can be asked to suggest how the other elements can have similar electron configuration with the noble gases and achieve lower energy?

Let them discuss with their bench mates. Then wait them for some time, so that they can come up with some kind of solutions.

Some students may tell that the elements should gain or lose electrons in the outer most shells to have similar electron configuration as the noble gases. If not, help them to come to this generalization. Explain that if elements have 8 electrons in their outer shell, they are said to have attained the octet rule. .

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Students may be asked to write the different electronic structure of noble gases and how it contributed to their stability.

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Now students should conclude why we don't find most elements free in nature. All elements have the tendency of having the noble gas configuration. To attain this, the elements gain, lose or share electrons. In their last shell as the result, different types of bonds:, ionic covalent or metallic bonds are formed. That is why we don't find elements in a free form.

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- Define ionic bonding
- Describe the formation of an ionic bond

- Give examples of simple ionic compounds

Materials

Charts of models of different ions and ionic compounds
Two types of Styrofoam balls one of tennis ball size and the other about half of tennis ball size as many as possible

Note for the teacher;

This lesson is a lesson that should be delivered next to a lesson on ion formation in the sub-topic "formation of ionic compounds"; i.e the second lesson of the three lessons on ionic bond formation.

Start this lesson, by explaining that metal atoms give electrons and form cations, whereas non-metals lose electrons and form anions. These two attract each other by the electrostatic attraction force between oppositely charged ions to form ionic bond. Therefore, ionic compounds are made up of non directional bond in which all the oppositely charged ions attract each other in all directions and like charged ions repel each other. However, the common misconception here is that students believe that ionic compounds like NaCl are diatomic molecule. They fail to understand that ionic compounds are aggregates of ions. So, this lesson is designed to further clarify ionic bonding by using Styrofoam ionic models. The use of the model is not to teach the three dimensional crystal structure which is beyond the scope of the lesson but to describe that an ionic bond is non directional and the ionic compounds do not have molecular particles.

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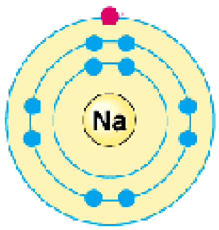
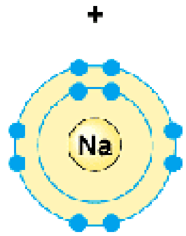
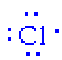
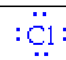
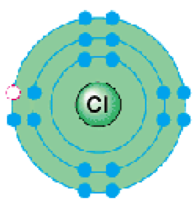
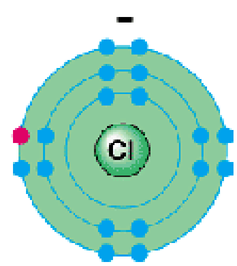
The lesson may be started by revising the formation of ions. You may write the symbols of some metals like Na, K, Mg and Al and that of the non-metals like Cl, F, O, and N; ask some students to write ionization reaction (i.e. lose of electron for the metal atoms to form cation and gain of electron for the non-metals to form anion) , some of them to write electron configuration of the atoms and their ions, the rest to write Bohr's models for the atoms and ions and finally Lewis/dot formula of the atoms and the ions. In this way you can involve many students in the revision activities.

It is also important to remind students about the interactions between opposite and like charges from their physics lessons.

Make sure that students successfully accomplish the above tasks as follows:

Na		Na^+	+	e⁻
$1s^2 2s^2 2p^6 3s^1$		$1s^2 2s^2 2p^6$		
2, 8, 1		2, 8		
Na•		Na^+		
				
Cl	+	e-		Cl^-
$1s^2 2s^2 2p^6 3s^2 3p^5$				$1s^2 2s^2 2p^6 3s^2 3p^6$
2, 8, 7				2, 8, 8
				
				

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Students may be asked the following questions

How do metals form ions? What type of ions do they form? What are the ions called?
How do non-metals form ions? What type ions do they form? What are the ions called?
How big or small is the relative size of the cation as compared to its atom?
How big or small is the relative size of the anion as compared to its atom?
What do we call the electron configurations of the cations and anions?
With which elements' configuration do they have similarity?
What are the interactions between opposite charges? What about between like charges?

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Students may be asked to predict what happens when sodium and chlorine atoms are brought together. Let them discuss around their table, write down their impression and report to the class.

Some students may come up with correct answers from their previous knowledge of octet number and electron gain and lose. The others may be unable to bridge the last and the present concepts.

Using the more able students' ideas you can assist the class to associate the concepts of formation of cations and anions and electrostatic attraction between oppositely charged particles.

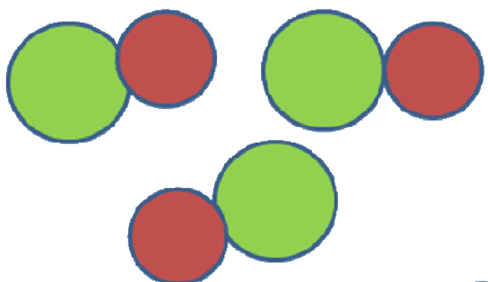
Let students exercise writing formation of cations and anions and their attraction to form ionic bond using Bohr models, Lewis symbols and chemical reactions as shown in the starter activity table of this lesson.

Now ask students which structure they would choose for sodium chloride formed when atoms of sodium and chlorine combine.

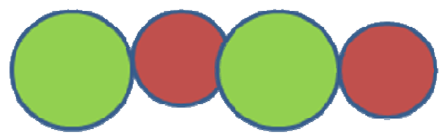
Consider the smaller red sphere as sodium cation and the green larger one as chloride ion.

Which of the following is the most likely structure for sodium chloride?

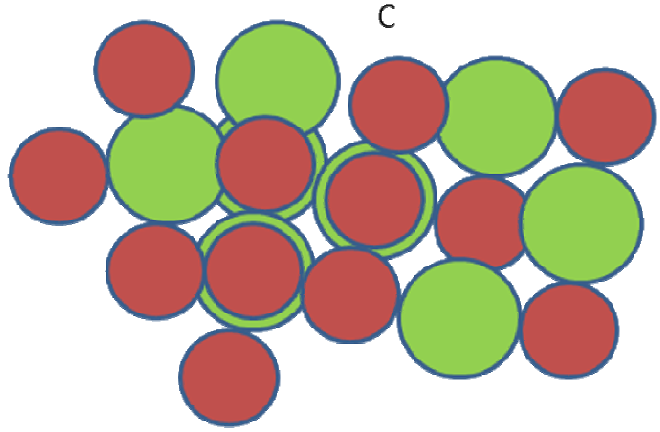
A



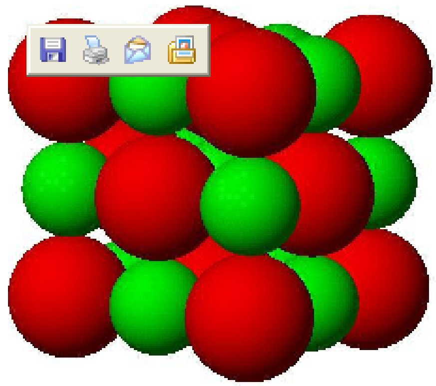
B



C



D



Students may tend to choose “A” as a model for the structure of sodium chloride because probably they think that it is made up of separate molecules. However, it should be clear that each positive sphere or cation, attracts the opposite charged anions in all direction and the anions also attract the cations in all directions. As a result the number of anion surrounding the cation depends on the relative size of the ions. As there are forces of attractions between opposite charges and forces of repulsion between like charges, oppositely charged ions are placed as close as possible and the like charged ions as far apart as possible. In the case of sodium chloride each sodium ion is surrounded by six chloride ions and each chloride ion in tern, is surrounded by six sodium ions Such repetitive arrangement of the ions form a giant structure.

Now instruct the students to construct a three dimensional structure for sodium chloride using the atomic models or Styrofoam balls and a glue or gum.

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1. Colour the larger and smaller balls with different colours.
2. Take the small ball as a representing sodium ion and keep it on the table.
3. Paste the larger balls of chloride ion on the two sides, the top side at the bottom, the front and back sides of the sodium ball.
4. Do the same thing for each of the anions also by surrounding them by the cations.
5. Continue the construction with many balls as you have.

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1. What is the ratio of the number of sodium ion to the number of chloride ions in sodium chloride?
2. How many sodium ions are there around each chloride ion?
3. How many chlorides are there around the sodium ions?
4. The following chart shows part of a periodic table.

Group Period	IA	IIA	IIIA	IVA	VA	VIA	VIIA
1							
2	A				G	D	

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3		B	C				E
4	H	F					

Answer the following questions based on the table.

a. Which elements lose electrons to attain an octet of electrons in their outermost shells?
b. Which ones gain electron to attain octet number?
c. Element _________ loses three electrons to form a cation.
d. Element _________ gains three electrons to form an anion.
e. Write down the formulas of ionic compounds made up of the following pairs of elements.

i. A and E
ii. H and D
iii. B and E
iv. C and G
v. F and D
vi. C and E

f. Write down Lewis formula for the ionic compounds that would result from the combinations given in question (e) above

Answers to the questions

1. 1:1 2. 6 3. 6 4. a. A, B, C, H, F b. G, D,E c. C d. G

g. i. AE ii. H_2D iii. BE_2 iv. CG v. FD vi. CE_3

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Students may be asked to complete the following paragraph using the appropriate terms.

Ionic bond is made by the electrostatic attraction force between (1) ________ and (2) ________ ions that are formed from (3) ________ elements and (4) _________ elements by losing and gaining electrons respectively. Ionic bond is also called (5) ________ bond. In ionic compounds all the anions are surrounded by (6) ________ and cations are surrounded by (7) ________; but the cations and anions depends up on the number of (8) ________ gained and lost. Ionic compounds can be represented by (9) ________ formula in which the dotes are used instead of (10) _______ of the atoms.

1. catios
2. Anions
3. Metals
4. Non-metals
5. Electrovalent
6. Cations
7. Anions
8. Electrons
9. Lewis
10. Valence electrons

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- Investigate the properties of given samples of ionic compounds
- Test hardness and brittleness of NaCl, $CuCl_2$ and $CuSO_4$
- Test solubility of NaCl, $CuCl_2$ and $CuSO_4$ in water, ethanol, acetone and toluene
- Apply scientific methods

Materials

5Test tubes, 3 beakers, stirrer, mortar and pestle, watch glass, spatula, water, NaCl, $CuCl_{2,}$ $CuSO_4$, paper clips, tongs, copper foil; table sugar, plastic substances available in the lab or in the surrounding, table salt and other salts available in the laboratory, sulphur, charcoal liquid substances like water, alcohol, oil,

Note for the teacher

Students may memorize the general properties of ionic and covalent compounds listed in their text books. However, they may generalize that all compounds soluble in water are ionic. But some compounds like table sugar are polar covalent. Similarly they may think that all substances which conduct electricity in solution form are ionic, but polar covalent compounds such as acids can do so. We know that ionic compounds have high melting and boiling points, but there are other covalent substances like diamond silicon carbide which have extremely high melting points. Even regarding brittleness, if you hammer a crystal of table sugar, it breaks into pieces like ionic compounds. So, all this exceptions should not mislead students when identifying compounds. We understand from these facts that a single shot test only cannot be used to identify a compound, but series of tests.

These experiments are qualitative, as a result the outcomes of tests are relative and we usually say high or low. This can be clearly understood if we use other non ionic substances for comparison.

Therefore, in the next series of experiments students should predict the results of the experiments before they conduct and make observations.

Consider two experiments on hardness or brittleness and solubility considering that these activities can be completed in a period. The rest of the experiments on properties of ionic compounds melting point and conductivity can be conducted in the same way. If materials are limited to deliver for groups of students to conduct the activity, you can demonstrate it in such a way that all students can see. Students should write predictions about the results of the activity before they are conducted, observe all the activities, and write their observations and conclusions on their notebooks. The format for data collection can be written on the chalk board.

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Keep a collection of different materials and compounds on a table. These can be different metal substances like paper clips, tongs, copper etc; table sugar, plastic substances available in the lab or in the surrounding, table salt and other salts available in the laboratory, sulphur, charcoal liquid substances like water, alcohol, oil, etc.

Tell students to come to the table one after the other to identify ionic substances from the rest of substances. Let them give reasons for their identification.

If the students were introduced to properties of ionic compounds, they will easily skip discard liquid substances, since they also know metals like copper, non-metals like sulphur, they will exclude them. They may comfortably identify table salt as an ionic compound because they are familiar to it.

Generally students may fail to make further identifications.

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Students may be asked whether or not it is easier to identify ionic compounds by simple observation. What can we do to identify them?

Obviously students suggest that it is difficult to know whether a compound is ionic or not by observation and they may recommend laboratory activities.

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1. Hardness and brittleness of ionic compounds.

   Prediction

   A. Write your opinion about the following

      a. What do you feel if you press a grain of ionic compound between your fingers strongly? Is it strong or soft?
      b. What will happen if you hammer a grain of an ionic compound? Will it be shattered or flattened, or doesn't make any change?

   B. Activity and observation

      a. Hold a grain of sodium chloride between your fingers and press it.
      b. Keep a crystal of sodium chloride on a mortar and press it with a pestle
      c. Repeat the same procedure for copper (II) chloride and copper sulphate

      Write down your observations. Are they the same with your predictions?

   C. What do you generalize from your observations?
   D. Analysis of the experimental findings

      Why did ionic compounds show those properties during the activities?

2. Solubility of ionic compounds

A. Prediction

   a. If you add some solid ionic compound in water of a beaker and stir, will it dissolve?
   b. How about in solvents like ethanol, toluene or acetone?

B. Activity and observation

   a. Add a spatula of sodium chloride into a beaker half filled with water and stir.

      Write your observation. Is it in agreement with your prediction?

   b. Repeat the procedure (a) using ethanol, toluene or acetone as a solvent.
   c. Add a spatula full of sodium chloride in a test tube half filled with ethanol. Stir and observe what happens.
   d. Repeat procedure (c) in ethanol and acetone or toluene as a solvent
   e. Now repeat procedures (a) to (d) using copper (II) chloride and copper (II) sulphate and write your observations
   f. Complete the following table based on your observation by putting a mark for soluble and × mark for insoluble

Ionic substance	**Solubility in various solvents**				
	Water	Ethanol	Acetone	Toluene	Hexane
Sodium chloride					
Copper (II) chloride					
Copper (II)sulphate					

C. What do you generalize from your observations?
D. Analysis of the experimental findings

   Why do ionic compounds show the properties you observed in the activities?

Based on their previous lessons and on results of the activities, students can write down the observations and generalizations. However, they may be unable to analyze the findings. You can assist them to relate their observations to their lessons on formation and nature bonding.

In this case they should come to the conclusion that

Ionic compounds are hard because they are formed by strong electrostatic forces of attractions between oppositely charged ions
They are brittle because when external force is applied upon them, it brings like charges close together. As a result, the crystal shatters due to the repulsive force operating between oppositely charged ions
Ionic compounds dissolve in polar solvents like water based on the principle of like dissolves like. Since ionic compounds are made up of ions, they dissolve in solvents which are polar or having dipoles.
Substances like alcohol and toluene or hexane have no dipole and hence they are called non-polar compounds; as a result, they cannot dissolve polar substances like ionic compounds.

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Students can be asked what property of ionic compounds they investigated, what result they found and why these results are obtained.

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Let the students summarize the lesson in the following table. Write the table on the chalk board and ask students to complete the table.

Properties of ionic compounds	**Observation**	**Reasons or explanations**
Hardness		
Brittleness		
Solubility in polar solvents		
Solubility in non polar solvent		

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Explain polarity in covalent molecules
Distinguish between polar and non polar covalent molecules

Material

Charts with diagrams of different types of molecules with different inter molecular forces

Note for the teacher

Students may have difficulties in understanding intermolecular forces. For example they may think that the whole system of solid or liquid covalent compounds is formed by covalent bonding. More likely that is the reason why they believe covalent bonds are broken when a substance changes state. They may think that when water boils, the vapor contains hydrogen and oxygen atoms. Indeed, they may attribute decreased melting and boiling points of covalent substances to weak covalent bonds.

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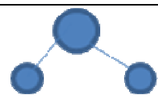
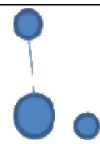
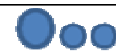
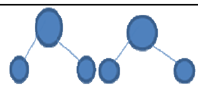
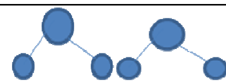
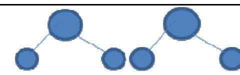
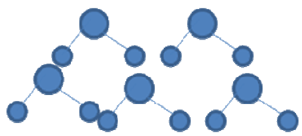
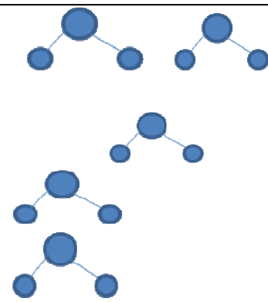
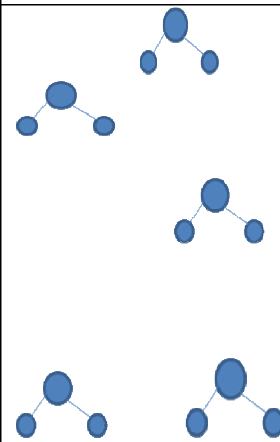
This lesson may be started by asking students background knowledge on their preconception about inter molecular forces from their daily life experiences.
Let them discuss across their tables the following:

How do you explain the changes of state in water? Consider the angular shape as water molecule; the larger sphere as oxygen and the smaller as hydrogen. Choose the correct graphic description of the changes of state among the alternatives 1, 2 and 3.

If students assume presence of covalent bond breakage during a change of state they prefer graphic description 1. On the other hand if they have imagined that there is no change at particle level during change of state, they choose description 2.

However, students should come to the conclusion that there are attractive forces between the molecules of substances. This forces breaks up during a change of state from solid to liquid and then to gas. They already know from their lower grades that physical changes do not involve change of composition. However, most students fail to relive and link concepts.

You can now explain intermolecular forces are attractive forces which hold the molecules together. On the other hand intra-molecular forces are chemical bonds like ionic and covalent bonds that hold the atoms together to form a molecule or a compound.

Substance	Ice	water	water vapor
Physical state	Solid	Liquid	Gas
Description 1			
Description 2			
Description 3			

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You may ask the students the following questions

1. What is intermolecular force?
2. What is the difference between intra-molecular force and intermolecular force?

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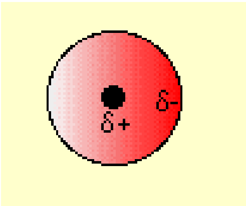
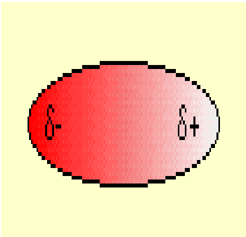
Let the students perform the following activity. Given the molecules: HCl, H_2, O_2, HBr, H_2O, NH_3, Ne, HI and He; let them

1. Classify the molecules into polar and non polar molecules
2. Match the class of molecules to the following diagrammatic representations.
3. What type of attractive force can hold each class of molecule?

Figures

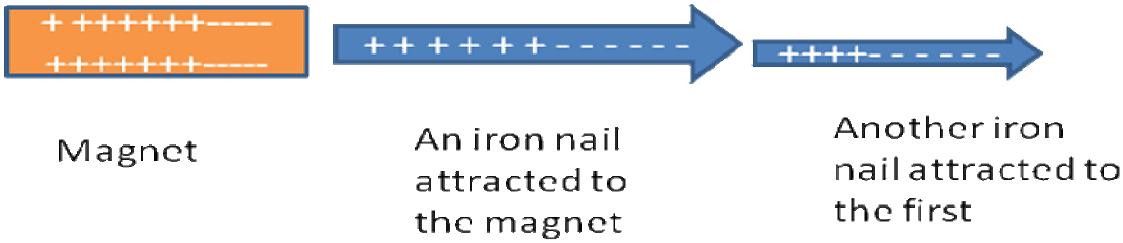
1. 

2. 

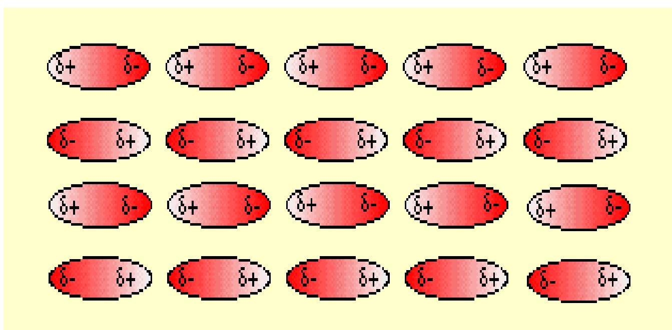
Let the students discuss in groups across their table and try to associate the concepts of polarity and non-polarity to the molecules and find out their representation from the given figures.

Some students can successfully match the polar molecules to the polar figures and tell that the positive and negative terminals attract each other. But still some of them may unable to link the concepts. Let the able students explain their observations and then you can give summary afterwards that polar molecules have dipoles due to the difference in the electro negativity of their constituent elements. The molecules align themselves with the positive terminal close to the negative terminal. So, due to the electrostatic attraction between the partial positive and partial negative charges, the molecules develop intermolecular attractive force which is called dipole-dipole attraction force.

The second groups of molecules can be explained by analogy as follows. When you take a positive terminal of a magnet to an iron nail, the nail is attracted to the magnet. This is because the positive end of the magnet pulls the electrons in the nail forward and causes the other end to be positive. If you bring another nail closer to first nail, it is attracted in the same way as the magnet did to the first nail. So, the magnet developed opposite charges into the first nail and the first nail induced the charge into the second nail.



Molecules can induce charges into one another in the same way. The electrons in the molecules are continuously vibrating. This instantaneous motion of electrons shifts them to one end at one time and to the other end at another time. When one end becomes negative due to the accumulation of electrons, the other end becomes positive. The charged molecule then develops induced dipole in to the neighbouring molecules. As the result the molecules attract each other. Such force is called instantaneous dipole- instantaneous dipole attraction force. It is also called London force after its discoverer, the German-American physicist, Fritz London.



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You may ask the students the following questions

1. What do we call the forces which act between molecules?
2. What is the difference between the intermolecular forces of polar and non polar molecules?
3. Give examples of molecules which experience each type of force.\

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Let the students discuss on the properties of the substances which are influenced by the intermolecular forces. Challenge them by giving clue to explain properties like melting point, boiling point that depend on intermolecular forces.

Students should also know that the two types of intermolecular forces they studied above are collectively called Van de Waal's forces. London force is the weakest of all the intermolecular forces and exists in all kinds of molecules.

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- Define chemical reaction
- Give some examples of chemical reactions

Material

Acetic acid, sucrose (table sugar), ammonium chloride, $NaHCO_3$ (baking soda), H_2SO_4, barium chloride $BaCl_2$, $Ba(OH)_2$, test tubes, beakers, spatula, stirrer, test tube holder, goggle

Note for the teacher

The challenge in teaching chemical reaction is to enable students understand the interaction between substances at a particle level. Even if we assist them conduct experiments on chemical reactions, the phenomena could not be clear for the students. They fail to understand that chemical reaction is the rearrangement of atoms, which involves bond breaking and bond formation. They think that in chemical reactions like combustion, there is destruction of matter.

So, we need to use different atomic and molecular models to describe interactions between particles.

This lesson is designed to make students attentive and arouse their curiosity through the whole unit. It enables them to understand the difference between physical and chemical processes clearly.

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You may start the lesson by asking the students to list some physical and chemical changes. Let them try to identify the difference between the two changes. From unit two in grade 7 chemistry, they may remember a number of changes like changes of state, melting, boiling, condensing, freezing of water and changes like breaking of clay, tearing of paper, cutting of wood etc as physical changes.

On the other hand, they might mention burning of paper, rusting of iron, souring of milk, fermentation of injera paste etc as chemical changes. You should appreciate any change they mentioned and list them on the chalk board.

Let the students discuss the basic differences and characteristics of each type of changes across their table with friends and forward their idea to the class.

Make a table of the following kind so that students use it to compare and contrast characteristics of the two changes.

Physical change	Chemical change

Some students may not be able to understand some of the properties of physical and chemical changes. In this case you may help them by explaining points like reversibility, changes in composition, formation of new substances and changes of energy.

You may inform the students that chemical changes involve change in composition and changes in composition can be described by using symbols and formulas.

Example: the rusting of iron,

Iron changes to rust, meaning Fe changes to $Fe_2O_3.H_2O$ by taking oxygen and moisture from the air. In souring of tella, the alcohol (C_2H_5OH) undergoes oxidation to an acid known as acetic acid (CH_3COOH)

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What are the characteristics of a chemical change? How do you describe the chemical changes in substances?

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The following activities can serve as starter activities for the students to explore chemical reactions. If you have materials and chemicals available for groups of students it will be preferable to make students conduct the activities by themselves. Otherwise, it is possible to demonstrate the reactions so that the students follow up all the steps and record their observations.

Procedure

1. prepare a worksheet in advance (if you are unable to provide a print-out worksheet, you can write the format on the blackboard)
   a) What are the starting materials in the chemical change?
   b) Write down what you expect when the starting materials are subjected to change.
   c) Write down the appearance of the starting materials before the change.
   d) Write down your observations during the changes. After each reaction, identify any indicators of a chemical reaction— change of color, change of energy, change of odor and evolution of gas.
   e) What are the final products of the changes?
   f) Try to describe the changes using words, symbols and formulas.
   g) Give reasons for the changes you observed.
   h) Write down your conclusion.
2. Activities

a) Baking soda and vinegar ($NaHCO_3$ and CH_3COOH)

1. Set out two beakers.
2. Pour about two table spoons of vinegar into the first beaker.
3. Now, take about two spatula of baking soda into the second beaker.
4. Pour the vinegar from the first beaker into the second beaker.
5. Watch as the two chemicals react.
6. Clean up any spills.

b) Sucrose (table sugar) and sulphuric acid ($C_{12}H_{22}O_{11}$ and H_2SO_4)

1. Take a tea spoon of table sugar on a watch glass.
2. Use a dropper to add some concentrated sulphuric acid to the sugar.
3. Observe and register your observation in your worksheet.

   Caution concentrated sulphuric acid is highly corrosive. Use gloves when you are working with it

c) Ammonium chloride and barium hydroxide (calcium hydroxide) (NH4Cl and $BaCl_2$ or $CaCl_2$)

1. Prepare solutions of ammonium chloride (a white paste material in a dry cell battery) and barium hydroxide (calcium hydroxide can be used alternatively) in separate beakers.
2. Hold a test tube with a test tube holder and add about 15ml of ammonium chloride.
3. Then slowly add barium hydroxide and observe what happens.

d) Barium chloride and sulphuric acid ($BaCl_2$ and H_2SO_4)

1. Dissolve some barium chloride in a beaker.
2. Add about 20ml of the solution to a test tube
3. Add 20ml of diluted sulphuric acid to the barium chloride solution in the test tube.
4. Now observe what happens.

Encourage the students to complete their worksheet and appreciate the different characteristics of chemical reactions. Let them discuss on the changes they observed.

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1. Which of the reactions released heat energy?
2. Which one formed a product with different colour?
3. Which one formed a gas product?
4. Which one formed a substance with unique smell?
5. What do all this observations tell you about the changes?

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What are the characteristics of a chemical reaction? How do we represent a chemical reaction? Define a chemical reaction using your own words.

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- Balance chemical equations using inspection method
- Balance chemical equations using the Least Common Multiple Method (LCM)

Materials

Charts for formulas of molecules, picture of bicycle, tricycle and automobile

1. Monocycles

Teacher's Note

Writing and balancing chemical equations should begin after students managed to write the correct formula of a compound and understand the qualitative and quantitative meanings of symbols, formulas and equations.

In balancing chemical equations, students do not easily understand why they should not change subscripts as far as they are able to make the number of atoms on both sides equal. This lesson should be given as the second lesson in sub-topic 4.3 Chemical equation after students studied writing chemical equation.

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The lesson can be started by revising writing chemical equation and its qualitative and quantitative meanings. Students may individually be asked the steps of writing an equation. Let them write the word equation of a given reaction and change it to skeletal equation.

For example reactions between: hydrogen and oxygen, sulphur and chlorine, sodium hydroxide and hydrochloric acid, calcium carbonate and sulphuric acid.

Let them tell the qualitative and quantitative meanings of their equations. Many students should take part in this revision.

When describing the qualitative and quantitative meanings students may misuse the terms molecules for non-molecular compounds like NaOH and $CaCO_3$. Help them to use ‘formula unit’ instead of molecule. But they can use mole in both cases.

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What are the qualitative and quantitative meanings of the chemical equation?

$$\mathbf{NaHCO_3 + CH_3COOH \quad CH_3COONa + CO_2 + H_2O}$$

Answer

1. Qualitatively it means, sodium bicarbonate reacts/combines with acetic acid to produce/yield/give sodium acetate, carbon dioxide and water.
2. Quantitatively

    a. One formula unit of sodium bicarbonate reacts with one molecule of acetic acid to produce one formula unit of sodium acetate, one molecule of carbon dioxide and one molecule of water or
    b. One mole of sodium acetate reacts with one mole of acetic acid to produce one mole of sodium acetate, one mole of carbon dioxide and one mole of water. or
    c. 84g $NaHCO_3$ reacts with 60g CH_3COOH to produce 82g CH_3COONa, 44g CO_2 and 18g H_2O

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The analogy of assembling vehicle bodies

Procedure

1. Make students into groups based on your class size
2. Tell them the following story.

   A factory manufactures vehicle bodies (monocycle, bicycle, tricycle and automobile) and buys tyres from another manufacturer to make a complete vehicle. The tyre manufacturer sells the tyres only in pairs.

   The vehicles producer wants to make sample vehicles with minimum number.

3. Ask the students to discuss in their groups to find out the minimum number of each vehicle the manufacture assembles and the number of each type of tyre, he buys so that no tyre is left unassembled.
4. Let them support their explanation by drawings
5. Let them match/associate the assembly of each of the vehicles to one of the following reactions

   a. $Mg + Cl_2 \quad MgCl_2$
   b. $Li + F_2 \quad LiF$
   c. $C + H_2 \quad CH_4$
   d. $Al + Br_2 \quad AlBr_3$

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1. To what parts of the vehicle are the Mg, Li, C and Al do you relate? How about Cl_2, F_2, H_2 and Br_2?
2. Can the vehicle be functional if any of the body or the tyre is missing?
3. If you want to make 5 tricycles how many tyres do you buy?
4. If you have 10 tyres how many cars can you assemble?

Concluding activity

Give them more advanced reactions to balance.

1. Sodium reacts with chlorine gas to produce sodium chloride
2. Lead (II) nitrate reacts with potassium iodide to produce lead iodide and potassium nitrate.
3. Potassium chlorate decomposes to form potassium chloride and oxygen
4. Propane burns to produce carbon dioxide and water
5. Sodium reacts with calcium chloride to produce sodium chloride and calcium
6. Hydrogen reacts with oxygen to produce water
7. Carbonic acid decomposes to form carbon dioxide and water
8. Phosphoric acid reacts with calcium hydroxide to produce calcium phosphate and water.

Let them explain why the formulas cannot be changed during balancing. Let them associate balancing equation with the laws of chemical reaction.

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- List the four types of chemical reactions
- Conduct experimental activities on the types of chemical reactions
- Identify the type of a chemical reaction
- Write chemical equations for each type chemical reaction.

Materials:

Test-tubes, Burners, Tongs, Test-tube holders, Medicine droppers

Note for the teacher

Here are some selected chemical reactions for demonstration; it is hoped that these simple reactions are used to stabilize students understanding of chemical reaction and the association of theoretical knowledge to practical activities. As usual, you can provide materials for groups if they are available or demonstrate yourself by participating students in the process. The lesson can be provided at the end of the types of chemical reaction to sum up the contents.

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As a starter activity, types of chemical reactions can be revised. They may be asked: how many types of reactions are there, their names, examples and special features of each type of reactions.

Here students are expected to list combination (synthesis), decomposition, single displacement and double displacement reactions, write their general equations and give specific examples of each type of reaction.

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Let the students write examples of types of reactions on the chalk board.

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Demonstrate the following types of chemical reactions. Follow the directions for each reaction carefully. After conducting each experiment, record your observations. Identify the types of reactions, the reactants and products and then write the balanced chemical equation for the reactions.

YOU MUST WEAR SAFETY GOGGLES DURING THIS LAB ACTIVITY!

Activity1.

a) Using a pipet, place about 1 mL (one pipet-full) of ethanol (C_2H_6O) on a watch glass.
b) Using a safety lighter or matches ignite the ethanol and allow it to burn completely.
c) Do not touch the hot watch glass!

Activity 2:

a) Obtain a small piece of copper wire or a few strands of copper wool.
b) Using tongs, hold the copper in the hottest part of a Bunsen burner flame and heat for approximately 1 minute. (Have someone tilt the burner as you heat so that copper doesn't enter the burner).
c) Allow the product to cool and then dispose of it in the trash.

Activity 3:

a) Pour approximately 25 mL of hydrogen peroxide (H_2O_2) into a 250 mL beaker.
b) Add one of the following A small chunk of potato or A spoonful of potato slurry or A very small spoonful of active dry yeast
c) Observe the reaction for approximately one minute. When finished, pour the solution down the drain with plenty of water.

The potato and yeast are not directly involved in this chemical reaction. What is their purpose?

Activity 4:

a) Obtain a small piece of iron wire. If the wire is rusty, clean it thoroughly with a piece of sandpaper until it is shiny. Then, coil the end of the wire around a pen or pencil.
b) Pour approximately 20 mL of copper (II) sulfate solution into a small beaker.
c) Dip the coiled end of the wire into the copper solution for about 10-20 seconds and then remove.

Activity 5:

a) Combine one pipet-full of 0.5 M calcium chloride and one pipet-full of 0.5 M sodium carbonate to a test tube.
b) When finished, dispose of the contents of the test tube down the drain and rinse thoroughly.

Activity 6:

a) Add approximately 150 mL of tap water to a 250 mL beaker.
b) Add 10-15 drops of the acid-base indicator of your choice (record this in your observations).
c) Add 5-10 drops of sulfuric acid to the water. Note the color of the indicator.
d) Continue to add drops of sodium hydroxide until you get a permanent color change. Again, note the color of the indicator.

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e) When finished, pour the contents of the beaker down the drain.
f) If time permits, you may repeat this experiment with another indicator.

Let the students report their observations and conclusions as follows. One example is given for each type of task.

Activity	Observation	Type of reaction	Chemical equation
1	• Ethanol is burned With pale blue flame • It reacted with oxygen in the air • Heat energy is given out		
2		Combination /synthesis reaction	
3			$2H_2O_2$ $2H_2O + O_2$

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Let the students discuss and write down the general features of the chemical reactions based on their observations. They may be asked a question as: 'How do you describe each type of chemical reaction?

After students discuss and give their own description of the reactions, make sure that they included the following information in their statements.

Combustion reaction is rapid chemical reaction of two or more substances with a characteristic liberation of heat and light; it is commonly called burning. The burning of a fuel (e.g., wood, coal, oil, or natural gas) in air is a familiar example of combustion

Decomposition reaction is separation of a substance into two or more substances that may differ from each other and from the original substance. The separation may be caused by heat, light, catalyst or electric energy.

A **combination reaction** or a **synthesis reaction** is a reaction in which two or more reactants are chemically bonded together to produce a single product. When two or more substances combine to form a single product, it is known as a combination reaction. Many elements react with one another in this fashion to form compounds.

A **single-displacement reaction**, also called **single-replacement reaction**, is a type of oxidation-reduction chemical reaction when an element or ion moves out of one compound and is replaced by another.

Double displacement reaction is the reaction in which two compounds react by an exchange of ions to form two new compounds. A double displacement reaction usually occurs in solution and one of the products being insoluble or precipitates.

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Students may be asked to define each type of chemical reaction and give example using chemical equation.

Concluding activity

You may different types of activities to assist students conclude their lesson on types of chemical reactions. Some examples are given below.

Activity 1

Match the types of reactions under column A with their descriptions under column B

A	B
1. Synthesis	a. Ions in a compound switch places with ions in another compound to form two new compounds
2. Decomposition	b. A single element replaces another one in a compound
3. Single replacement	a. Elements or less complex compounds come together to form a single more complex compound
4. Double replacement	d. A compound breaks apart into either elements or less complex compounds

Activity 2

Identify the type of reaction shown in each of the following chemical equations:

a. $KClO_3(s) \quad 2KCl(s) + 3O_2(g)$

b. $AgNO_3(aq) + KCl(aq) \quad AgCl(s) + KNO_3(aq)$

c. $2\,H_{2(g)} + O_{2(g)} \quad 2\,H_2O_{(g)}$

d. $HBr(g) + Cl_2(g) \quad HCl(g) + Br_2(g)$

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- Define limiting and excess reactants
- Determine limiting and excess reactants of a given chemical reaction
- Show that the amount of product of a chemical reaction is dependent on the limiting reactant

Materials

Charts with different diagrams: automobile bodies, tyres, atomic and molecular models

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You can start this lesson by discussing the analogy of tyres and assembly of an automobile body. Let the student do the following activity in groups.

The automobile body manufacturer produced six car bodies while the tyre company supplied 20 tyres.

1. How many tyres are required for each car?
2. What is the ratio of the car body to the number of tyres?
3. Are all the car bodies and the tyres used up?
4. How many cars can be assembled?
5. Is it the car body or the tyres which is in excess?
6. Which one limits the number of cars that would be produced?

After discussing this analogy students surly come up with the correct answers as it is easier to understand.

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Which part of the car limits the amount of car that will be produced? Why?

In this case make sure that the students clearly understand that the first step to such task is finding out the ratio between the parts which are used up to make a complete product. Excess and limiting are relative terms that are based on the established ratio. Students should not have the misconception that a limiting reactant is a substance which is lower in number/quantity or excess reactant is the one which is large in quantity/number.

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You may give the following task to the students to do according to the procedure below. Let them explain each step analogous to the assembly of the vehicle parts.

A 2.00 g sample of ammonia is mixed with 4.00 g of oxygen. Which one is the limiting reactant and how much excess reactant remains after the reaction has stopped?

Procedure

1) Write down balanced equation for the reaction.
2) Find out the number of moles of the reactants that combine according to the balanced equation.
3) Change the given masses of the reactants to their respective number of moles.
4) Compare the ratio of the numbers of moles of the balanced equation and the moles you calculated. Are the ratios the same or different?
5) Calculate the number of moles of NO or H_2O produced using the number of moles of ammonia you calculated.
6) Repeat the calculation in procedure 5 using the number of moles of oxygen you calculated.
7) Which calculation yielded less numbers of moles of the product?
8) Which result is the correct amount of the product formed? The larger or the smaller?
9) Which reactant limits formation of the product?
10) Do all the reactants that are mixed in the reactor converted to the product? Which one is left uncombined? How many moles of the excess reactant remain uncombined?

Hopefully students can accomplish the task because it is split into small and simple activities. However, students should be supervised and assisted where ever they faced difficulty. Finally you may check their work whether it consists of the following points for each step.

1) The balanced equation for the reaction is

$$4\ NH_{3(g)} + 5\ O_{2(g)} \longrightarrow 4\ NO_{(g)} + 6\ H_2O_{(g)}$$

This is analogous to assembling the parts of the vehicle to make a complete vehicle.

2) The ratio of number of moles of ammonia to oxygen is 4: 5. Meaning 4 moles of ammonia reacts with 5 moles of oxygen. This is as one car body is to four tyres, meaning 1:4.
3) Number of moles of ammonia, nNH3 = actual mass of ammonia/molar mass of ammonia

   = 2g / 17g/mole

   = 0.118mole

   Number of moles of oxygen, O_2 = actual mass of oxygen/molar mass of oxygen

   = 4g/32g/mole

   = 0.125mole

4) When the ratio is compared, 4:5 for the balanced equation and 0.118:0.125 for the given data, it comes to be 0.8 and 0.944. This means the reactants are not taken according to the balanced equation. We can see that unless spare parts are taken according to the proportion of parts for one complete vehicle, some are left unassembled.
5) According to the balanced equation for the reaction, to calculate the amount of water formed using ammonia:

$4\ NH_{3(g)} + 5\ O_{2(g)} \longrightarrow 4\ NO_{(g)} + 6\ H_2O_{(g)}$

4 mole NH_3 produces 6 mole H_2O

0.118 mole NH_3 produces x mole H_2O

X = 0.118 mole NH_3 x 6 mole H_2O/ 4 mole NH_3

= 0.177 mole H_2O

6) The amount of water formed using oxygen:

$4\ NH_{3(g)} + 5\ O_{2(g)} \longrightarrow 4\ NO_{(g)} + 6\ H_2O_{(g)}$

5 mole O_2 produces 6mole H_2O

0.125 mole O_2 produces y

Y = 0.125 mole O_2 x 6mole H_2O/5 mole O_2

= 0.15 mole H_2O

1. Calculation based on the amount of oxygen produces less amount of the product, water.
2. The smaller amount of product is the correct yield of the reaction because the larger amount is the result of the excess reactant
3. The amount of oxygen limits formation of the product. This means there is no enough amount of oxygen to combine with all the ammonia available in the reaction.
4. All the reactants are not converted to the product. Some amount of the excess reactant, ammonia, is left over in the reaction mixture uncombined. There are two different ways of calculating the amount of ammonia left uncombined. One is using the amount of product (water or nitric oxide) formed in the reaction while the second is using the amount of the limiting reactant, oxygen.

Let us use the amount of oxygen. Since we know that all the oxygen taken in the reaction combines to form the products, the amount of ammonia combined with the 0.125 moles of oxygen can be calculated as:

$4\ NH_{3(g)} + 5\ O_{2(g)} \longrightarrow 4\ NO_{(g)} + 6\ H_2O_{(g)}$

4 moles NH_3 reacts with 5 moles O_2

X reacts with 0.125 mole O_2

Mole of NH_3, x = 4 moles NH_3 x 0.125 moles O_2/5 moles O_2

= 0.1 mole NH_3

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This shows only 0.1 moles ammonia reacted with 0.125 mole of oxygen. Therefore, the amount of NH_3 is:

0.118 mole – 0.1 mole = 0.018mole NH_3 or

17g/mole x 0.018mole = 0.306g NH_3

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Students can be asked the following questions to check their understanding.

1. What are limiting and excess reactants?
2. Why does the amount of the product formed depend on the limiting reactant?

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Let the students discuss

The importance of balanced equation in the calculation of amounts of reactants and products and

What happens if the reactants are not mixed according to the proportion established by the balanced equation?

Students should come to the conclusion that unless the equation for a chemical reaction is balanced, one cannot determine the proportion of the reactants that are combined. Balanced equation is a pillar for stoichiometric relationships. If reacting substances are not combined according to the ratio of the balanced equation, one of the reactant becomes excess and the other limited.

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- Define redox reactions
- Define the terms oxidation and reduction in terms of electron transfer

Materials: rusted iron materials, salt solutions of less active metals preferably copper sulphate or silver nitrate and metal strips like iron, zinc and Al.

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Let the students' brain storm about rusting of iron. Ask them why does iron rust.

After discussing round their table let them share their ideas to the class.

You may write down students' ideas on the chalk board. Challenge the students with the points they forwarded by asking them to reason out their views. You may remind the students how metallic elements react during the formation of ionic compounds.

Let them explain what exactly happens to the metal atoms during the reaction. This may lead them to understand the process of electron losing and gaining.

Evaluation

Is rusting of iron physical or chemical change?

Does iron lose or gain electrons during rusting?

What will happen to the charge of an iron atom?

Feedback

Students know from their lower grades that rusting is a chemical change. They may also know that rusting is the reaction of iron with oxygen. As this reaction is an example of a reaction between a metal and a non-metal, students may tell that iron loses electrons in the process and develops a positive charge.

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Demonstration of oxidation reduction reactions

Procedure

1. Fill a test tube with a solution of copper sulphate or silver nitrate to a one third.
2. Insert one third of an iron strip/nail into the solution.

3. Wait for about three minutes and observe what happens.

a. What change is observed on the part of the iron nail that is immersed in the solution?
b. Why do you think this change happens?
c. Is the change chemical or physical?
d. Describe the change using a chemical equation.
e. Does this reaction resemble the displacement reaction you studied in types of reactions? Explain.

After students discussed and responded to the questions you can use the opportunity to explain the electron transfer process. Definitions can be given for oxidation, reduction, oxidizing agent and reducing agents in terms of copper ion and iron atom.

You may start your explanation with the observation. When Zn or Fe is introduced in the solution of $CuSO_4$, the observations are:

The size of the metal strip starts to reduce showing that it reacts in the process.
The colour of the copper sulphate solution gets faded. This is also an indication that the cause of the blue colour, Cu^{+2}, is consumed in the reaction.
Deposition of copper metal is the other indication of conversion of Cu^{+2} to Cu.
The reaction can be represented by the chemical equation

$$CuSO_4\ (aq) + Zn(s) \quad ZnSO_4(aq) + Cu\ (s)$$

To show the change in the charge or oxidation number of the species, you can write ionic equation for the reaction.

$$Cu^{+2}SO_4^{-2}\ (aq) + Zn^0(s) \quad Zn^{+2}SO_4^{-2}(aq) + Cu^{\ 0}(s)$$

Now identify the actual changes that occur in the reaction.

1. $Cu^{+2} \quad Cu^0$
2. $Zn \quad Zn^{+2}$

Let the students try to explain the meanings of these changes. After they forwarded their opinion, explain that a decrease in charge/oxidation number of the ions means an acceptance of electrons and an increase in the oxidation number is a loss of electrons. The electrons lost by one of the species of a chemical reaction are accepted by the other species.

Therefore, the species which gain electron or whose oxidation number decreased are said to be **reduced.** In our particular example Cu^{+2} is reduced because its oxidation number is reduced from +2 to 0. This happens because copper ion gained two electrons. The process is called **reduction**.

On the other hand, the species which loses electrons or whose oxidation number increased is said to be **oxidized** and the process is known as **oxidation.** Zn is changed to Zn^{+2} by losing two electrons or its oxidation number is changed from 0 to +2.

The students should then understand lose of electrons is oxidation and gaining of electrons is reduction.

Let again students discuss the other aspect of the oxidation and reduction. Ask them what caused copper ion to be reduced and what caused zinc ion to be oxidized.

What caused Cu^{+2} to be reduced? Or what donated electrons to Cu^{+2} to make Cu^{0}? Help the students to point out that it is Zn atom which gave two electrons to Cu^{+2} to make Cu^{0}. A species which causes reduction of the other species by giving electrons is called a **reducing agent**. Therefore, Zn is a reducing agent in the above example.

What caused Zn to be oxidized? Or what takes its two electrons so that it becomes Zn^{+2}? by the same token students can mention it is Cu^{+2} which accepted the two electrons. Therefore, a species which accepts electron of the other species to make it oxidized is called **oxidizing agent.** As the result Cu^{+2} in the above example is an oxidizing agent.

Students should also be aware that whenever there is a donor of an electron, there is always an acceptor of an electron. In the other words, oxidation can never happen in the absence of reduction. Oxidation and reduction occur simultaneously in the same reaction and the reaction is called **oxidation reduction** reaction or in short **redox** reaction. You can note the reaction equation for the above activity.

$$CuSO_4\,(aq) + Zn(s) \qquad ZnSO_4(aq) + Cu\,(s)$$

To avoid misunderstanding, assist students to bear in mind that there are two reactants that play opposing roles in the redox reaction. One is the reduced substance which causes oxidation of the other and called oxidizing agent. The second is the oxidized substance which causes the other substance to be reduced and called reducing agent.

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Let the students define the following in terms of electron transfer.

- Reduction
- Oxidation
- Reduced species
- Oxidized species
- Oxidizing agent
- Reducing agent

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Let the students review their lesson and classify the following terms into the two categories, oxidation and reduction.

- Oxidized substance

- Substance which gains electrons
- Reducing agent
- Substance which loses electron
- Oxidizing agent
- Reduced substance

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- Define a reaction rate
- Measure the rate of a chemical reaction
- Describe reaction rates using graphs

Materials

Gas syringe, conical flask, rubber tube, rubber stopper with one hole, magnesium ribbon, diluted hydrochloric acid graph paper

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Let students discuss the following issues in groups:

1. Do all chemical reactions have the same speed or different speed? Explain your view point by giving examples
2. Arrange the following processes according to the speed of reaction: rusting of iron, burning of splints of wood, burning of log of wood, fermentation of teff pate, burning of benzene.
3. Do you think that the speed of a chemical reaction has effect on the industrial production of goods? How?

Allow the group representatives to report their findings to the class. Encourage them to discuss and ask each other question. Students can successfully mention that chemical reactions vary in speeds, but may unable to give examples. The second discussion point can provide them a hint to explain how different process occurs at different speeds. Help students to come to the consensus that burning of benzene, burning of splint, burning of log, fermentation (which usually take about three days) and rusting of iron are the correct order of the process in decreasing speed. They should know that the speeds of chemical reactions differ in such a way that some take place immediately as the reactants come in contact, some have moderate speed and others take days and weeks and even more.

Students should also able to explain that the speeds at which chemical reactions take place influence production of industrial products. The more is the time taken during the reaction, the higher is the cost of the product.

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How do the speeds of chemical reactions vary?

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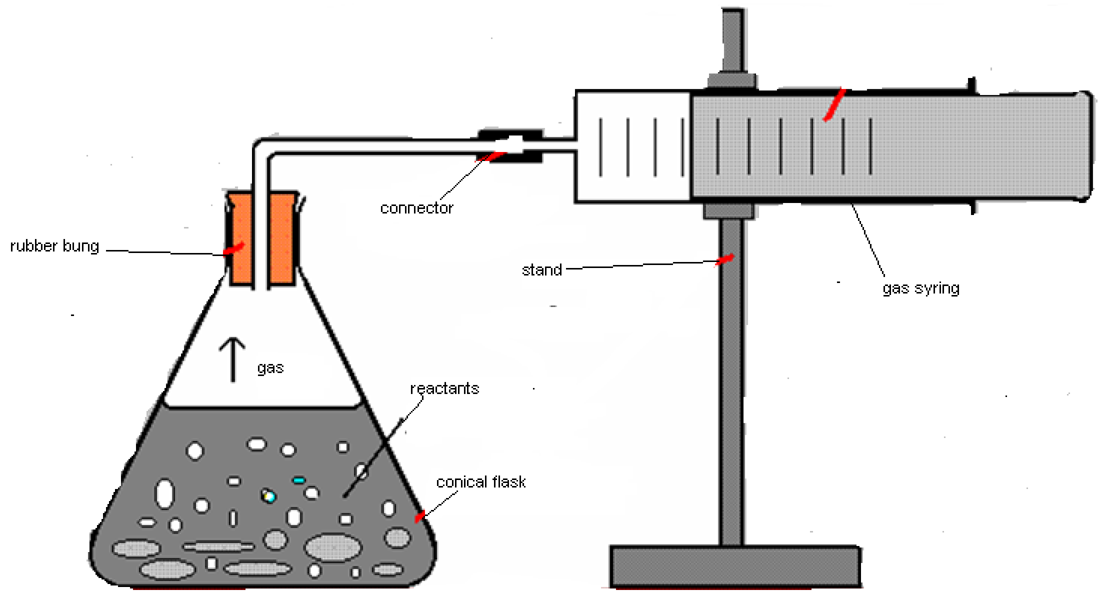
Measuring speed of chemical reaction

Procedure

1. Provide a conical flask, gas syringe, rubber topper, delivery tube, connector, magnesium ribbon and diluted hydrochloric acid to each group
2. Help them to assemble the apparatus as in the figure.
3. Let them add about 50ml of diluted hydrochloric acid to the conical flask
4. Then drop 5cm magnesium ribbon in the acid and stopper with the rubber stopper attached to the syringe.



5. Record volume of the gas at 20 seconds time interval as follows.

Time (s)	20	40	60	80	100	120	140	160	180	200	220
Volume of gas(cm^3)											
V/t											

6. Draw a graph of time the (x-axis) against volume of the gas evolved(y-axis)

Let the students discuss and respond to the following questions.

a. How the volume does vary in all the 20s intervals? (Constant, increase or decrease)?
b. What does the ratio of the change in volume to change in time represents?
c. How do you compare the speed of the reaction in the first 20s and in the last 20s?
d. Write down a chemical equation for the reaction.
e. What happens to the amount of the reactants as time passes?

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f. How about the amount of the product?
g. What do you call the speed with which the amounts of the reactants and products change?

Based on their observations students should give the following responses.

The volume at different intervals continuously decreases
The ratio the change in volume to change in time gives the rate of a chemical reaction
The speed continuously decreases
$Mg + 2HCl \quad MgCl_2 + H_2$
The amount of the reactants decreases and the amount of the products increases as time elapsed.
The speed of change of amount of the reactants and the products are the measures of the rate of chemical reactions.

Conclusion

Encourage students to write down conclusions

a. How do you measure the speed of reaction of magnesium and hydrochloric acid?
b. Does the rate of the reaction of magnesium with hydrochloric acid increase or decrease as time elapses?
c. What is the ratio of change in volume of hydrogen to change in time during the reaction of magnesium with hydrochloric acid?

Generalization

Let them write how the rate of a chemical reaction can be determined and what happens to the reactants and products during the reaction. Let them also interpret the graph.

Evaluation

Students may be asked the following questions:

What is the rate of a chemical reaction? How is the rate of a chemical reaction measured?

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Let the students write down mathematical expression for the rate of a chemical reaction in terms of change in concentration of the reactants or the products.

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- Explain properties of gases
- Give the kinetic molecular theory explanation for the properties of gases
- Give examples of the properties of gases

Materials

Charts for arrangements of the different physical states of substances, balloons, syringes,

Note for the teacher

The difference between the three physical states of matter is the type of interactions among their particles. These interactions depend on the intra-molecular and intermolecular attractive forces students investigated sofar in unit three. The important point in the study of gases is identifying the properties and their kinetic molecular theory explanations. Students usually have difficulty of understanding that most of the space in the gases is empty. So, they should be able to explain, describe and give kinetic molecular theory explanations of the properties of gases.

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This lesson can be started by reviewing the kinetic theory of matter. Let the students discuss the kinetic theory of matter.

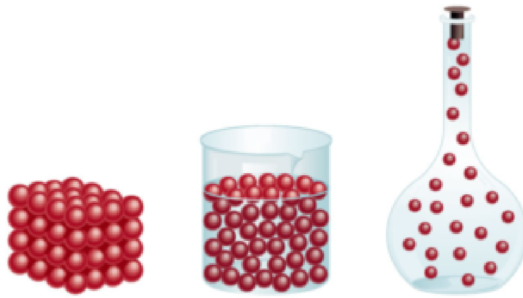
Procedure

1) Make the students in groups depending on your class size
2) Let them discuss the three assumptions of the kinetic theory of matter
3) Instruct them to use small sphere drawing to represent molecules of substances
4) They should use pencil and paper to describe their understanding of properties of gases, liquids and solids under the same conditions.
5) Let the group representatives present their findings of the difference between the three physical states.

This presentation will create a good opportunity to know the students' conceptualization of the kinetic theory of matter.. Questions and answers should be encouraged during the discussion and presentation. Students may come up with different views and drawings. However, you may use the correct explanation and drawings to harmonize their ideas.

The following points may be highlighted to explain the assumptions

- Particles of matter can be atoms, ions or molecules. These particles are moving continuously; the gas particles move randomly colliding with other molecules and with the wall of their container. Liquids are neither as random as gases nor as restricted as solids. Particles of liquids can roll over one another and mix up. The solids are restricted to vibrating to their mean positions.
- The motions and positions of the particles of matter make them to have kinetic and potential energies.
- The gas particles are more energetic than liquid particles and liquids particles are more energetic than solid particles.



Evaluation

Students may be asked to point out the differences between gas, liquid and solid states based on the explanation of the kinetic molecular theory.

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Discussing and giving explanation on properties of gases

Procedure

1. Let the students continue the starter activity in groups
2. Provide them balloons, syringes, balances
3. Read properties of gases on your text book page 168 and the kinetic molecular theory on pages 170 and 171.
4. Explain properties of gases giving by kinetic molecular theory explanation.
5. Use different materials as examples to describe and demonstrate your explanation
6. Report your findings in tabular form as follows

Property of a gas	Kinetic molecular theory explanation	Description examples

Let the group representatives present their discussion points and demonstrations in group. As usual discussions should be encouraged. Finally they should come to the consensus like the following

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Property of a gas	Kinetic molecular theory explanation	Description examples
1. Gases have no definite shape and definite volume	**Assumption 1** The particles are in the state of constant, rapid and random motions	They may blow balloons of different shape and size and show the effect
2. Gases can easily compressed	**Assumption 2** The space between the particles of gases are very far	They may sack gas with syringe, close the mouth of the syringe with their finger and try to compress
3. Gases have low densities compared with liquids and solids	**Assumption 2** As density is mass per unit volume, gases have low density because they have small number of particles in relatively large space of volume	They may measure mass of a balloon full of gas and some millilitres of water in the similar balloon.
4. Gases exert pressure in all directions	**Assumption 1** Gases collide with wall of their container continuously in all direction. This collision exerts pressure on their container.	They may blow the balloon and see that it inflates in all directions.
5. Gases easily flow and diffuse through one another	**Assumption 3 and 5** No attraction force between particles, their kinetic energy depend on their temperature	They may release the mouth of the balloon they blown to see gas flowing out.

Evaluation

Procedure

1. Each student should have three small cards of green, yellow and red colours. It can be made up of Manila paper or old document folders.
2. You would state the properties of gases and their explanation one after the other.
3. Students raise their cards in response; the green for agree, the yellow if they are not sure and red if they didn't understand the idea at all.

This helps you to know how much of the students have internalized the lesson. Then you can invite students with green cards to explain for those with red cards. Finally you may correct students' responses if necessary.

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Let students discuss applications of gas in daily life.

They may mention points like:

- Air fills into the tyre of vehicles and exerts pressure
- Light gases are filled into balloons for scientific researches and recreations etc.

Lesson that can be taught by similar methods are:

Properties of liquids
Properties of solids

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Competencies

- Explain vapour pressure
- Determine vapour pressure of a liquid
- State the factors that affect vapour pressure of a liquid
- Give examples of the effects of vapour pressure from daily life

Materials

Diagrammatic representation of vaporization

Note for the teacher

The lesson of vapour pressure can be contextualized because students have experiences in their day-to-day activities. The most important point is understanding what happens at particle level during vaporization and why do different liquids have different vapour pressures? Students should also understand the concepts such as volatility and viscosity since they encounter them in their lives frequently. To depict the concept of vapour pressure it is advisable to conduct the experiment on the student textbook page 193.

The lesson can be started by inviting students to discuss the process of cooking and boiling in the kitchen at home.

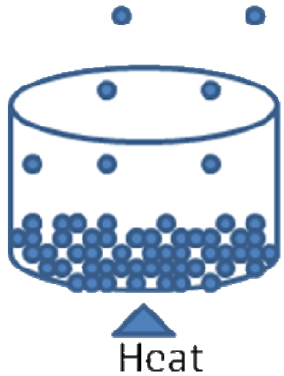
Let the students discuss round their desks the following points;

- When food is cooked in a closed container, why does the inner part of the cover gets wet after some time?
- Sometimes the cover of the cooking utensil flips of by an internal effect. Explain these phenomena in chemical terms.
- Use figures to explain your ideas.

Give them some time and ask them to explain their understandings.

Although the concept seems simple, students may come up with different views regarding the phenomena. Some of them may say ‘the liquid is splashed up to the cover”, the others may think simply the surroundings of a liquid is usually wet like river sides. Some the students may guess that liquid vaporizes and condenses on the cover.

Regarding the removal of the cover of the cooking utensil, they may also think that the liquid it self pushes the cover. Some of them may unable to imagine that vapour pressure has such energy. They should also be able to draw figure like the following one.



Evaluation

What makes the cover of the cooking utensil wet during cooking?

What pushes the cover off the cooking utensil?

Main activity

Now you may define vapour pressure as the partial pressure developed above a liquid. Let the students investigate the factors that affect vapour pressure of a liquid by doing the following activities

Organize the students in to groups and give them to the following activities to discuss and come up with kinetic theory of matter explanations.

Activity 1

If you keep equal amount of water in equal sized open beakers, the first being under temperature of 20^0C and second under temperature of 45^0C , the content of the second water reduces significantly than the first one.

Activity 2

If you keep equal amounts of benzene and water in equal sized open beakers under the same temperature, the volume of the benzene reduces significantly in the same time.

a. Use the concept of intermolecular forces of attraction to explain the difference.
b. How do you classify the two types of liquids?

The group representatives should present their observations to the class. The class may ask questions and discussion should be extended among students.

You should assist the students in their discussion to associate the concepts to the kinetic theory of matter and the intermolecular forces of attraction.

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Students should come to the understandings like:

- According to the kinetic theory of matter, the particles possess kinetic energy and potential energy. The kinetic energy depends on the temperature of the particles. As temperature increases the kinetic energy of the particles increases, as a result they become more energetic to overcome the attraction force of the neighbouring molecules. Likewise, the particles of the water at temperature of 45^{0}C obtain more kinetic energy than they were at 20^{0}C. Therefore more molecules escape from the former resulting in more reduction of the volume in a given period of time.
- When benzene and water are compared, water possesses strong intermolecular attraction force between its molecules which is known as hydrogen bonding. But benzene has very weak intermolecular forces of attraction, i.e. the London force. At the same temperature, more energy is required to break the forces between the water molecules than benzene molecules. So, more benzene vaporizes than water in a specific period of time.
- Substances which vaporize at lower temperature like benzene are called volatile substance. Volatile substances are substances having weak intermolecular forces. They usually have higher vapour pressure than the non-volatile substances at a particular condition of temperature and pressure.

Evaluation

Students can be asked question like:

1. What are the factors that affect vapour pressure of a liquid?
2. What are volatile liquids?

Concluding activities

Let the students discuss and classify the following substances as volatile and non-volatile. The substances are: ammonia, water, benzene, ethanol, perfume, sulphuric acid, and edible oil.

Check whether the students can perform the classification as

Volatile	**Non-volatile**
Ammonia	Water
Benzene	Sulphuric acid
Ethanol	Edible oil
Perfume	

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Demonstrate an experiment to show the phase changes from ice to liquid water and then to water vapour

Explain the phase changes

Describe the processes of phase changes

Explain the energy changes in phase changes

Materials

Pyrex beaker of 200ml, thermometer, tripod with wire gauze, stirrer, stand with clap, crashed ice (voluntary students may be asked to bring from nearby village),

Note for the teacher

The concept students understand in this activity is the latent heat of vaporization and latent heat of fusion. These concepts can only be clear when practically performed. Students should be able to explain why temperature is not raised at melting points and boiling points. To understand this, careful performing, recording and analysing of the data is required. Therefore, students should be assisted to conduct and observe the activity.

You may start the lesson by revising changes of state. This can be done by matching terms used for the processes of changes with the changes.

Procedure

1. Write each term on each of the same coloured card and the descriptions on the other with different kind of colour.
2. Provide the two series of cards for each group of students.
3. Let the students match card of the correct process or change to the descriptions.
4. The terms can be

   - Vaporization
   - Condensation
   - Deposition
   - Crystallization
   - Sublimation written on one kind of card

5. The processes are:

- Change of gas to liquid
- Change of solid to liquid
- Change of liquid to solid
- Change of gas to solid
- Change of solid to gas written on the other.

Check whether the students successfully matched or not and help them when there is a problem.

Evaluation

Students may be asked questions like:

1. Classify the following processes as endothermic and exothermic: Vaporization, Sublimation, Condensation, Deposition and Crystallization
2. Given the following energy changes, pair the ones which are the reverse of one another. Heat of crystallization, heat of fusion, heat of condensation, heat of deposition, heat of vaporization and heat of sublimation

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Let the students do the activity in groups if there are available materials. If not you can demonstrate the experiment by involving the students.

Procedure

1. Add the crashed ice into the beaker
2. Put the beaker on the tripod with wire gauze
3. Insert a thermometer into the ice and fix it with a clamp of the stand so that it will not touch the bottom of the beaker.
4. Heat the ice in the beaker, measure the temperature and record the temperature every 30seconds
5. Continue your observation and recording until the water boils
6. You may record your data in table as follows

Time (s)	0	30	60	90	120	150	180	210	240	270	300
Temperature (^{0}C)											

7. Draw a graph by using time on the x-axis and temperature on the y-axis.

Analysis

1. What was the phase of the content of the beaker at the beginning?
2. To what temperature was the thermometer reading raised at the beginning?
3. What was the phase during the first constant temperature?
4. What has happened at this temperature?

5. At what thermometer reading was the second raise in temperature observed? To what temperature was it raised?

Conclusion

1. What do you call the first temperature at which the thermometer reading was constant?
2. Why doesn't the temperature raised while the heating process was continued?
3. What was the purpose of the heat consumption during the constant temperature?
4. Why was the temperature raised for the second time?
5. Why the temperature was remained constant for the second time? What do you call this temperature?
6. What do the compartments of the curve you drawn show?

Generalization

1. What is the melting point of ice at the particular conditions of your environment? How do you define melting point?
2. Why does temperature remains constant at melting point?
3. Why does temperature remains constant at boiling point? What is boiling point?
4. Are fusion and vaporization endothermic or exothermic processes?
5. Is it possible to reverse these processes?
6. What should we do to reverse the processes?

Let the group representatives present their observation, conclusion and generalization. The other groups can discuss the findings in comparison to their works. The following main points should be checked whether the students grasped or not?

1. Ice melts at about 0^0C (may be there is slight variation due to altitude)
2. Temperature remains constant at melting point until all the ice melts. The heat is consumed to break the intermolecular forces between water molecules instead of raising the temperature of the system.
3. Below the melting temperature the content of the beaker was solid, at a melting point the solid and the liquid coexist, between m.p and b.p liquid exists and above b.p liquid and vapour exist
4. Temperature remains constant at boiling point until all the liquid vaporizes. The heat is consumed to break apart the force between liquid molecules.
5. The heats consumed without raise in temperature are called latent heats. The first one is called latent heat of fusion while the second is latent heat of vaporization.

Evaluation

Students should be able to answer the following questions.

1. Why are melting and boiling endothermic processes?
2. What are latent heats of fusion and latent heat of vaporization?
3. How do you explain melting and boiling in terms of the relationship between particles of substances?

Make sure that students can successfully explain that during melting and boiling intermolecular forces break up; as the result heat energy is required.

Latent heats are heats that are consumed without raise in temperature.

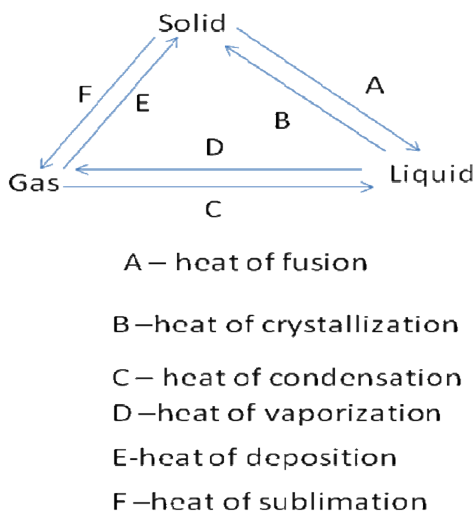
Particles are strongly attracting and are close to each other in solid crystals. Melting is then breaking this strong attraction force so that the particles can free to flow. In boiling particles of liquid which are still under attraction of each other are set completely free from each other.

Concluding activity

You can give the following activity to the students

Procedure

1. Draw a triangle using the words solid, liquid and gas at each corner of the triangle
2. Write double arrows with opposite direction between the vertices
3. Write the energy involved to change one phase to the other



Annexes

Sample lesson Plan

Name of teacher: **------------**
Subject: *Chemistry*
Date of lesson: **-------------**
Sub-unit of lesson: *Discovery of the sub-atomic particles*

Name of school: **-------------------------**
Grade and section: *Grade 9*
Unit of lesson: *The Structure of the Atom*
Topic of lesson: *Discovery of the Electron*

Competencies: After the lesson *Students will be able to*

- Explain the discovery of electron
- Describe properties of electron

Rationale of the topic: most of the properties of the elements like reactivity and bonding depend on the electrons in their atoms. The number of electrons and their arrangements in the atom are also the basis for the classification of the elements in the periodic table. Understanding the experimental procedures of the discovery of electron helps the students to know how scientific methods are used to explore in to the atoms.

Stage	Contents	Teacher's activities	Student's activities	Assessment activities
Starter activities(*5minutes*)	Review of the modern atomic theory	- Asking the students to state the postulates of the modern atomic theory - Jotting down the main points of the students' answers - Ask the to explain the postulates	- Students state the postulates giving explanations	- Ask how the modern theory amended the Dalton's atomic theory.
Concluding activities (7minutes) **ain activities**(28 minutes)	The cathode ray tube Properties of cathode rays	- Ask students to predict how scientists discovered particles in an atom. - Give brief explanation of the parts of the cathode ray apparatus and their functions using diagram - Asking students operates and let them reason out - Making students into groups. - Keep the charts of the cathode ray tube 1. with light paddle 2.with +ve and –ve electric plate where they can see. - Give them the following activities to explain the following observations giving reasons 1. the rays deflect to the +ve terminal of the electric plate 2. the light paddle in tube rotates when there are cathode rays 3. a cross obstacle on the path of the ray casts shadow on the screen 4. when Thomson used different materials the same rays are produced ask the students to give conclusion of the lesson	- They forward their ideas giving reasons. - Students closely observe the diagrams - They make discussion in groups Each group registers the findings of their discussion using the diagrams on the charts they may conclude that Cathode rays move in straight line because the obstacle on their path casts a shadow on the screen Cathode rays have masses because the paddle was rotated when it was strike by the ray. Cathode rays are negatively charged because they were attracted to the positive terminal of an electric field Cathode rays are contained in all substances because when different materials were used in the discharge tube, they show the same resultand present to the class.	- Ask them to describe how the apparatus works Asking why - the cathode rays deflect to the positive terminal - the paddle rotates - shadow cast - all substances show the same result Ask the students how from the experiment Thomson came to state - An electron carries a negative charge. - An electron is a fundamental constituent of all matter

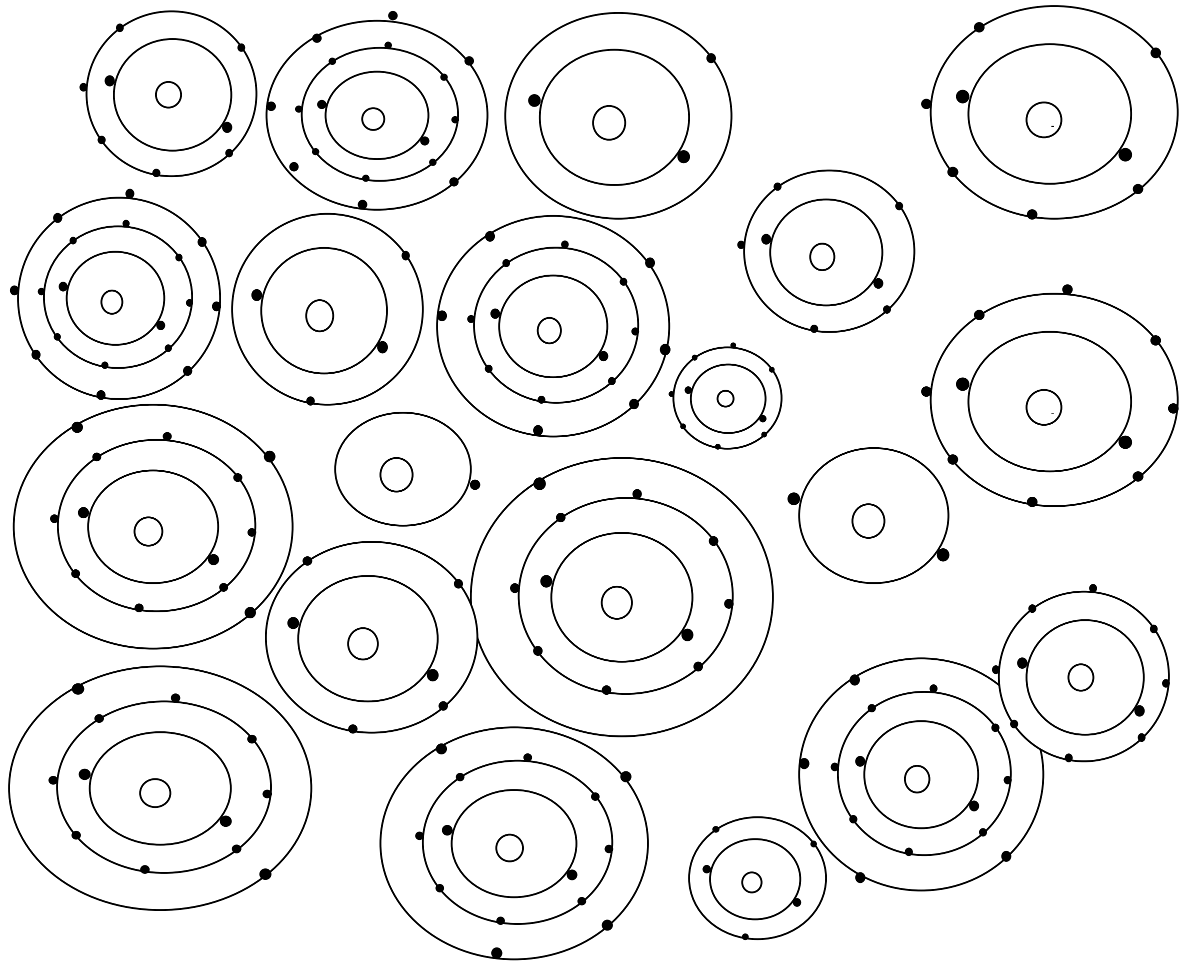
Figures: **The Periodic Table of the Elements**

GROUPS

	s-block		d-block										p-block					
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
	IA	IIA	IIIB	IVB	VB	VIB	VIIB	VIII			IB	IIB	IIIA	IVA	VA	VIA	VIIA	0
	ns^1																	ns^2np^6
1	$_{1}H$	ns^2											ns^2np^1	ns^2np^2	ns^2np^3	ns^2np^4	ns^2np^5	$_{2}He$
2	$_{3}Li$	$_{4}Be$											$_{5}B$	$_{6}C$	$_{7}N$	$_{8}O$	$_{9}F$	$_{10}Ne$
3	$_{11}Na$	$_{12}Mg$				$(n-1)d^{1-10}\ ns^{1-2}$							$_{13}Al$	$_{14}Si$	$_{15}P$	$_{16}S$	$_{17}Cl$	$_{18}Ar$
4	$_{19}K$	$_{20}Ca$	$_{21}Sc$	$_{22}Ti$	$_{23}V$	$_{24}Cr$	$_{25}Mn$	$_{26}Fe$	$_{27}Co$	$_{28}Ni$	$_{29}Cu$	$_{30}Zn$	$_{31}Ga$	$_{32}Ge$	$_{33}As$	$_{34}Se$	$_{35}Br$	$_{36}Kr$
5	$_{37}Rb$	$_{38}Sr$	$_{39}Y$	$_{40}Zr$	$_{41}Nb$	$_{42}Mo$	$_{43}Tc$	$_{44}Ru$	$_{45}Rh$	$_{46}Pd$	$_{47}Ag$	$_{48}Cd$	$_{49}In$	$_{50}Sn$	$_{51}Sb$	$_{52}Te$	$_{53}I$	$_{54}Xe$
6	$_{55}Cs$	$_{56}Ba$	57-71	$_{72}Hf$	$_{73}Ta$	$_{74}W$	$_{75}Re$	$_{76}Os$	$_{77}Ir$	$_{78}Pt$	$_{79}Au$	$_{80}Hg$	$_{81}Tl$	$_{82}Pb$	$_{83}Bi$	$_{84}Po$	$_{85}At$	$_{86}Rn$
7	$_{87}Fr$	$_{88}Ra$	89-103	$_{104}Rf$	$_{105}Db$	$_{106}Sg$	$_{107}Bh$	$_{108}Hs$	$_{109}Mt$	$_{110}Ds$	$_{111}Rg$	$_{112}Cn$						

f-block															
Lanthanoids	$_{57}La$	$_{58}Ce$	$_{59}Pr$	$_{60}Nd$	$_{61}Pm$	$_{62}Sm$	$_{63}Eu$	$_{64}Gd$	$_{65}Tb$	$_{66}Dy$	$_{67}Ho$	$_{68}Er$	$_{69}Tm$	$_{70}Yb$	$_{71}Lu$
Actinoids	$_{89}Ac$	$_{90}Th$	$_{91}Pa$	$_{92}U$	$_{93}Np$	$_{94}Pu$	$_{95}Am$	$_{96}Cm$	$_{97}Bk$	$_{98}Cf$	$_{99}Es$	$_{100}Fm$	$_{101}Md$	$_{102}No$	$_{103}Lr$

Bohr's Atomic Models of the First 18 Elements



Lewis formula of the first 20 elements

IA	IIA	IIIA	IVA	VA	VIA	VIIA	0
H•							•He•
Li•	Be	B	C	N	O	F	Ne
Na•	Mg	Al	Si	P	S	Cl	Ar
K•	Ca						

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