PART - II

TEACHING OF SCIENCE
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The term assessment is used in education in specific ways. It is used to determine the quality of performance of an individual or a group. It tries to find out what a student knows and the way (s)he responds performs a task in various settings. Some times confusion arises over the use of the two words ‘assessment’ and ‘evaluation’. In some contexts they are used synonymously. It is better to understand these as two distinct processes which educators use to help students build life long learning skills. These are used for different purposes. Assessment provides feedback on knowledge, skills, attitudes etc. for the purposes of elevating further performances and learning outcomes. Evaluation determines the level of quality or outcome of a performance and enables the evaluator to take decision on the basis of level of quality demonstrated. In short we can say that assessment helps in improving further performances while evaluation is to determine the quality of present performance. Therefore, assessment is followed by providing suggestions for improvement of performance. These two processes are complementary and necessary in education. Although assessment and evaluation have different purpose, similar steps are involved in both the processes. In both processes criteria is specified for determining the outcome of a performance. Both require the collection of data and other evidences to get information about the level of quality of performance.

Evaluation is the term used to describe the determination of the level of quality of performances. The evaluation process focuses only on the actual level of quality with no interest in why that level was attained. It is decision making about students’ performance and hence, about success of the teaching strategies applied by the teacher. It is a kind of judgment making – A teacher makes judgment about students’ performance and about his/her own strategies of teaching. For example teacher makes a judgment about student ‘A’ that his performance is poor in chemistry and he needs improvement or the student has performed better than (s)he in his/her earlier examination. The teacher may make judgment about his/her own strategies. For example, teacher makes judgment that her students performed poor in the topic atomic structure and tries to make changes in the teaching strategies or she judges that students do not have adequate basic knowledge to understand the topic atomic structure. In an evaluative report, only the information regarding the actual quality of the performance is given. This might be in the form of a grade or a score.
or an evaluative statement like ‘good work’, ‘average performance’ etc. The purpose of the evaluative report is to report the level of quality and possible consequences based on the determined level of quality. **It is not used to suggest improvement in further performances. Evaluation occurs when a level is assigned after completion of a lesson, task, test, quiz, or some other learning activity.**

**Measurement** is an evaluation expressed in quantitative terms(numbers). It is concerned with quantification of a trait or character in terms of number(s). Instead of saying that the student ‘A’ seems to understand /does not seem to understand the topic atomic structure, the teacher says that the student ‘A’ could answer only six questions out of ten questions on the topic atomic structure and secures 12 marks out of 20. Measurement allows a teacher to compare one student’s performance with respect to other students or the student’s performance on the particular task or to compare a particular student’s performance at different occasions. In an evaluation, certain attributes can not be expressed in quantitative terms. For example-

- Information from parents,
- Students’ preferences, interests
- Students’ attitudes, motivation, ability
- Intuition etc.

**Assessment** is a broader term. It includes all kinds of formal and informal information about the student’s skill, knowledge, abilities (for example - does the child emerge as a leader in the group?), attitudes attributes etc. Assessment requires gathering of evidences of students’ learning over a period of time. Evidence of student’s learning can be collected through paper pencil tests*, dialogue articles in the journals, other written work, portfolios, oral tests, presentation, project work etc. along with many other learning tasks. Assessment can go beyond paper-pencil test to observations and performances, the creation of artifacts etc. The term assessment is used when one looks at how the quality level of outcome of performance could be improved in future. Assessment demonstrates a sense of learning and clearer picture of a student’s ability. Assessment report informs about why a performance is good or poor. It describes how the future performances could be improved. **The report mentions strengths that should be sustained and the high priority areas that need improvement. Assessment process is concerned only with how to improve the level of quality.** If a child scores well (Evaluation) in a test of chemistry but is unable to apply the knowledge in daily life, the high scores matter a little. Following example makes it clear.

Two students ‘A’ and ‘B’ appear before the interview board for obtaining a job in a pharmaceutical firm. Student ‘A’ passes the written examination with 85% marks and student ‘B’ passes the written examination with 75% marks. When student ‘A’ is asked to prepare 5N HCl, he fails to prepare the solution of correct concentration but the student ‘B’ successfully completes the task. The score of student ‘A’ is better than the score of student ‘B’ but student ‘B’ is better in practical skills. Naturally the interview board will **evaluate** the student ‘B’ to be more suitable for the job though the quantitative evaluation of the
students shows that performance of the student 'A' is better. Here no feedback is given for the improvement of the performance so the word evaluation has been used.

Assessment is the most complex task of teaching. Innovative instructional techniques enhance the scope of learning, while innovations in assessment provide teachers an insight into the complexity of what learners learn and how they use their knowledge. Therefore, a teacher needs to know the purpose and values of different assessment techniques and understand how they affect the learner. Before we begin to discuss different techniques of assessment, we should become familiar with the terms **formative and summative assessments** and an understanding of functions of these assessments.

**Formative assessments** guide the teachers in planning instructions and help students identify areas that need work. Often teachers give a formative test or ask some questions to students prior to instructions in the class. These questions or pre–test help the teacher to determine what students already know. This guides the teacher for planning the instructions. Sometimes a test is given during the instructions to see what areas of weakness remain; so that teaching can be directed towards the problem areas. This is generally called a diagnostic test. Students can apply the information received about their level of learning to improve their performance by re-teaching themselves. **Pretests and diagnostic tests are not graded.** This practice in test- taking is helpful to those students who become anxious in taking test when grading is done or marks are provided.

**Summative assessment** occurs at the end of the instruction. Its purpose is to let the teacher and the student know the level of accomplishment achieved. Final exam is the classic example of summative assessment. Summative assessment provides summary of students’ accomplishment. Chapter -1, the mole concept in the present package uses both the forms of tests. It should be noted that same assessment procedure can be used for either purpose.

In short we can say that **formative assessment is ungraded testing** used before or during instruction to aid in planning and diagnosis. Pretest is formative test for assessing students’ knowledge, readiness and abilities. Diagnostic test is formative test to determine students’ areas of weakness and summative assessment is a test that follows instructions and assesses achievement after completion of a task.

There is much agreement amongst science educators that traditional testing methods are not authentic. These fall short of measuring standards that are part of contemporary science education. They say that objective type tests do not require interpretation therefore it is difficult to measure complex learning. Also, some objective type tests may be answered by guessing or elimination. As far as essay type questions are concerned, it is difficult to score them objectively. Current thinking is that science instructions must be evaluated using quite different techniques and tools. Assessment procedures should be authentic. Such assessment requires students to perform some task and solve problems that are similar to the real–life performance and may be expected of them outside of school. These
performance tasks may be non traditional and require the student to think, create, demonstrate or perform. A student facing a difficult problem must experiment, he should imagine and test solutions, apply basic skills and inventive techniques. A student should become capable of making interpretations and should be able to decide the mode of communication to the audience. Student must accept the criticism and improve upon the solutions. This means that if our instructional goals are to develop abilities to write, communicate, listen, create, think critically, do research, solve problems or apply knowledge then our tests should ask students to do all these. Authentic tests identify students’ strengths. These tests minimize needless, unfair and demoralizing comparisons and allow appropriate room for student’s learning styles, aptitudes and interests. Observing what students write, say and do, can form the foundation for assessing performance. Projects, interviews, conferences, presentations, journals, logs of data, lab reports, extended studies, portfolios, exhibitions, project work, student’s self assessment etc., are examples of performance tasks that can provide evidence of what student’s understand.

The purpose of a performance task is to assess what the students know and what they can do with that knowledge. The reliability and validity of performance assessment parallels that of traditional assessments. Performance tasks should consist of complex challenges that reflect problems and issues faced by adults. These tasks should be meaningful and worth measuring. Typically, the student undergoing assessment knows in advance the goal, the role, the setting, the product or performance and the standard against which work will be assessed. The performance task given to the student for summative assessment after completion of study of a unit should activate prior knowledge and let the student know where (s)he needs to shape the performance tasks. For this, following criteria may be used:

- It should be meaningful, authentic, challenging, thought provoking and interesting.
- Should have content appropriate to the cognitive level of the student.
- Should stress on depth of the topic instead of vastness of the topic.
- Allow for multiple approaches, solutions and answers. Path of action should not be very clear at the very beginning.
- Raise the questions and lead to other problems.
- Integrate knowledge and skills within the disciplines of science, language, arts, and mathematics.
- Offer students an opportunity to demonstrate their understanding of science and just not provide a single, best, and often superficial answer.
- Serve to link the unit, lesson and performance.

Teachers should have a goal of assessment in their mind before they design their own tests or evaluate questions for using a particular test. If students are given test on the material soon after learning and retested on the material later, the tests are especially effective in promoting learning. Frequent testing encourages the retention of information. The retesting should be spaced farther. Cumulative questions in which students have
to apply and integrate knowledge to solve the problem, lead to effective learning. Learning is more if more time is devoted to review, practice, testing and feedback.

**ASSESSING ACHIEVEMENT ON PERFORMANCE TASKS**

Performance assessment requires careful judgment on the part of a teacher and clear communication to the student about good work and what needs improvement. **Judgment is not the ultimate goal of the assessment. Improvement of learning is the ultimate goal.** Therefore, performance assessment is based on observing the student’s performance on a variety of tasks and comparing his/her performance to a standard. Performance tasks can not be evaluated by using paper-pencil tests. Performance tasks are usually open ended and seldom have single correct answer. Before challenging the students to attempt a performance, the teacher should explain the task, discuss and give the student written criteria, which should be well understood by every one before students’ performance begins. To carry out assessment of performance of a student, teacher has to develop scoring rubrics. These are rules that are used to determine the quality of students’ performance. A checklist or a rating scale gives specific feedback about elements of performance. Students should be involved in the development of rating scales and scoring rubrics. Some guide-lines for developing rubrics are as follows:

**Step-1** Show students the examples of good work and discuss with them what makes the work good. Also show the examples which lack the characteristics of good work.

**Step-2** Teacher should describe the best level, worst level and middle level of quality of work. Middle level can be decided on the basis of knowledge of common difficulties and discussion of what is not good work.

**Step-3** The checklist (scoring rubrics) developed in this way can be given to the students to score their peers and the same rubrics should be used by the teacher to score the students.

**Step-4** Now the students can be assigned the task and when they are performing the task, they can be stopped occasionally for self and peer assessment.

**Step-5** Give students time to revise their work based on feedback obtained by them.

First step is necessary for the new task. Rubrics for quality can be decided by the teacher when students become accustomed to this scoring system. As an example we will discuss the use of science journals for assessment of performance skills. For other tools of assessment, one may see the chapters in this package and consult source book on assessment for upper primary stage developed by NCERT.

**SCIENCE JOURNALS FOR ASSESSMENT**

**What is Science Journal?**

Science Journal is a record of children’s experience while learning science. A Science Journal provides the children an opportunity to record his/her observations, draw inferences from the observations and express
his/her own opinion and plans of modifications in the experiment, activity or a project work.

**Teachers’ task**

Before using the science journal as a tool for assessment the teacher should guide the children to structure their science journal. One way to guide the children is to provide the list of questions which the students will answer while writing the science journal. The questions should be such that they reveal the personal account of science experiences of the child while learning science. She/He may ask the students to draw illustrations in response to the answer of the question. Suppose the student performs the activity in the class himself/herself or teacher shows a demonstration to teach about the physical properties of metals. The teacher may ask the students to write their experiences under the following headings.

1. **What do I know about metals?**
   Answer of this question will reveal the previous knowledge of the student. The student may write – “I know that metals are hard they give sound on striking and we can heat them on flame”. This question should be answered by the students before they perform any activity or shown any demonstration.

2. **What shall I try to find out?**
   This question will help the child to define the problem. Several queries come up in the child’s mind while answering such questions. They think about extension of the problem. Students should answer this question before they perform the activity, see demonstration or do some project work or perform some experiment.

3. **What materials do I need for my task?**
   This question should also be answered before performing an experiment/performing an activity/starting a project work etc. Under this heading students list the material required for performing the task.

4. **How did I perform the activity/carried out the project work/carried out the experiment?**
   Here students record the proceedings of the task in stepwise manner. They write the details of actual activity/activities performed by them.

5. **What I found?**
   Here students record the data, observations, and writes formal record of findings. Data may be recorded in the form of a chart in the tabular form, graph etc.

6. **What do I conclude?**
   Under this heading, students write the inferences and conclusions in a logical sequence. This reflects their understanding.

7. **What in my opinion about the experiment/investigation/activity/demonstration?**
   Students express their opinion about the task they performed when
they answer this question. They may make connection with real life situation.

8. If I had to repeat the task what changes would I like to make?

This question stimulates thinking over the process of the project work/activity/investigation/demonstration etc. and leads the students to important findings. It helps them to learn the scientific process of investigation. It helps them to make a plan of an activity/investigation etc. It inspires the students for further discoveries.

It is not necessary that entries in the science Journal will always be made in the same form. Teacher may ask the students to write a letter to a friend about medicinal plants of daily use. They may draw cartoons to highlight the important conclusions.

Assessing student’s science Journal

Following rubric may help in assessing Science Journal

I Rubrics for assessing conceptual understanding –
(1) Evidence of conceptual understanding
(2) Evidence of change in conceptual understanding
(3) Realistic diagrams
(4) Link between conceptual understanding and real life situation

II Rubrics for assessment of Science Process –
(1) Problem stated clearly
(2) Procedure stated clearly
(3) Observations recorded properly
(4) Interpretation of data and drawing conclusion to state result giving logic of drawing conclusion
(5) Variables identified
(6) Analysis of investigation with suggestions for possible changes

Based on the guidelines for assessing science journal, teachers can develop rubrics for assessment of other performance tasks.

Performance assessment makes learning in the school system more relevant. Performance assessment takes the fear of learning science out because open ended questions have many correct answers. Taking the anxiety out of science classroom may motivate many more students to opt for studies in science. They will enjoy, learn and use more concepts of science. It helps teachers to focus on really important outcomes of science education instead of teaching isolated bits of information. A student learns to become a competent problem solver. They become confident of their ability to think logically and become capable to communicate their ideas clearly.

Grading and scoring standards of authentic tests involve criteria that assess performance and make self-assessment a part of the assessment. These use a multifaceted scoring system instead of one aggregate grade.

While determining the final grade, the teacher should make a major decision whether the grades of the students will reflect the amount of
material learned and how well has it been learned (criterion referenced grading) or will the grade reflect the student’s status in comparison to other students of the class (norm referenced grading)?

In criterion referenced grading, the grades represent a list of accomplishments. Clear objectives are set for the course. Criteria for each grade is spelled out in advance. It is then up to the student to earn the grade he/she wants to receive. If a student reaches the criteria she/he can achieve the highest grade. In norm – referenced grading, student’s standing in comparison with the other students of the same class is given. This type of grading system damages the relationship between students and between teachers and students.

The Point System and Percentage grading

One approach is that points are awarded on the test based on specific criteria. If tests of comparable importance are worth the same number of points, have same difficulty level and cover similar amount of material, this system can be fair and practical. If points are required to be converted to final grade then the problem becomes complex.

Another approach is percentage grading. The teacher can assign grades based on how much knowledge each student has mastered. To do this, the teacher might score test and class work with percentage score. These scores are then averaged to reach course score, which can be converted into letter grades according to predetermined cutoffs. For example 90-100% = O, 80-89% = A, 70-79% = B, 60-69% = C, %, 50-59% = D, 40-49% = E, below 40.0% = F. To use percentage grading appropriately, we would have to know exactly what was there to learn and exactly how much has the student learnt. So, it is also not foolproof.

The contract System and Grading Rubrics

In this system, type, quantity, and quality of work required for achieving each grade (A, B, C, etc.) is indicated. Rubrics describe the performance expected for each level. Students agree to work for (Contract) particular grades by meeting the specified requirements and performing at level specified. If clear and well developed rubrics describe the performance expected and students learn to use the rubrics to evaluate their own work, then quality and not the quantity becomes at the central point of grading.

Above guidelines give ideas for using any grading system in a fair and reasonable way. Every communication from the teacher need not be tied to a grade. Communication with students and parents can be important in helping a teacher understand students. It helps the teachers to present effective instructions by creating a learning atmosphere.

REFERENCES

**INTRODUCTION**

The word ‘mole’ was introduced around 1896 by Wilhelm Ostwald, who derived the term from a Latin word mole meaning a ‘heap’ or ‘pile’. A substance may be considered as a heap of atoms or molecules. In 1967, mole was accepted as SI unit to measure the amount of substance containing same number of molecules/atoms as in 0.012 kg of C-12 isotope of carbon. In SI units, the amount of substance is expressed in a unit named as mole. It’s symbol is ‘mol’.

Mole concept is one of the most feared and misunderstood concept in chemistry though it is a very simple concept. It seems, there is need of using different transaction strategies.

**KEY CONCEPTS**

- Mole is the method of ‘counting’ items and finding the mass of items that cannot be seen.
- Connection between mole concept and familiar counting unit like dozen.
- Relationship between number of moles and mass of a substance.
- Mole- item and item-mole, mole-mass and mass-mole interconversion.
- Application of mole concept to measure the amount of a given substance.

**PRIOR KNOWLEDGE REQUIRED**

Before learning about mole concept students should have –
- knowledge of basic mathematics.
- understood concept of atomic mass, molecular mass, formula mass.
- knowledge about calculation of formula mass.
- knowledge of using the balance.

**TRANSACTION STRATEGY**

**Inquiry based teaching**

**Preparation before teaching:**

- Packets of different seeds e.g. Green Bean (Moong Dal), Gram (Channa), Kidney Beans (Rajmah), Black Beans (Urad) etc. (Note: In place of seeds one can use beads of different sizes. Colour of beads may or may not be the same)
- Make four packets of each kind of seeds and label them.
- Weight box, balance etc. for weighing.
- Work sheets.
- Quiz questions etc. for evaluation.
This activity may be performed as a group activity. Each group will have three students. It will be nice if the students perform the activity themselves.

**Purpose of the activity:** To discover a method of counting things that cannot be seen.

**Initiating the activity**

Teacher can initiate the activity by interacting with the student as follows:

- When you buy bananas usually the shopkeeper tells you the price of one dozen bananas. You know that one dozen of any item means 12 items in number.
- Paper is not packed in dozens. It is packed in ream. A ream has 500 papers.
- Certain things are packed in gross. How many items are present in a gross? (Answer: 144)
- Suppose you want to design a new unit for counting. What would you consider for deciding the number of items in your counting unit?

(Note the answers given by students. Now students may be given instructions for performing the activity.)

**Teacher:** I name the new unit as ASHTAK. My unit contains eight items. How many items will you count in one ASHTAK?

(Answer: Eight)

Teacher: Like dozen if you have understood the meaning of an ASHTAK, you will be able to answer the following questions. (Work sheets will be distributed)

1. One ASHTAK of pencils will have ___________ pencils.
2. Three ASHTAKS of pencils will have ___________ pencils.
3. One ASHTAK of water molecules means ___________ molecules.
4. One ASHTAK of particles means ___________ particles.
5. One and a half ASHTAK particles means ___________ particles.
6. One ASHTAK of sodium atoms means ___________ atoms.
7. Six ASHTAKS of sodium atoms have ___________ sodium atoms.
8. Two and a half ASHTAKS of sodium atoms have ___________ atoms.
9. One ASHTAK of formula units of salt has ___________ formula units.
10. One fourth ASHTAK of formula units of salt has ___________ formula units of salt.
11. How many molecules are present in 800 ASHTAKS?
12. How many formula units are present in 600 ASHTAKS?
13. How many oxygen molecules are present in 0.5 ASHTAK of oxygen molecules?
14. How many chlorine atoms are present in 0.25 ASHTAK molecules of chlorine?
15. 64 atoms of chlorine are equal to how many ASHTAK molecules of chlorine?
Note For The Teacher

Discourage the answers of the questions given in the worksheet. After that proceed with discussion.

**Teacher:** You can imagine that bulk of one ASHTAK number of water molecules or one dozen water molecules cannot be seen through naked eyes; so scientists had to select a bigger unit for counting molecules of a substance. The unit is called MOLE. One mole of any thing has 602,200,000,000,000,000,000,000 items. This number is named as AVOGADRO number and in scientific notation it is written as 6.022×10^{23}. Thus, one mole contains 6.022×10^{23} items or we can say that one mole of a substance contains AVOGADRO number of items.

**Note For The Teacher**

Ask the students to recall how to multiply decimal numbers. An example similar to the following example may be used for this purpose.

5 × 6.022 × 10^{23} = (5 × 6.022) × 10^{23} = 30.110 × 10^{23} = 3.0110 × 10^{24}

**Teacher:** Now, if you have understood the meaning of mole, you will be able to solve the following questions (Worksheets will be distributed).

1. How many erasers will be present in one mole?
2. How many water molecules will be present in one mole of water?
3. How many water molecules will be present in half mole of water?
4. How many water molecules will be present in 2.2 mol of water?
5. 18.066× 10^{23} iron atoms are equivalent to how many moles of iron atoms?
6. 12.044× 10^{23} pencils are equivalent to how many moles of pencils?
7. 30.1 × 10^{23} molecules of water are equal to how many moles of water?
8. How many moles are 12.044 × 10^{23} formula units of a salt?
9. 5 moles of sodium chloride contain how many formula units?

**Worksheet**

**Activity 2**

*Purpose of the activity:* To establish relationship between number of moles and mass of a substance.

*Instructions to Students*

- Make groups of three students each or divide students in suitable number of groups and ask each group of students to collect one packet of seeds.
- Ask each group to fill Table-1 by weighing the required number of seeds.

**Table -1**

<table>
<thead>
<tr>
<th>S. No</th>
<th>Number of seeds</th>
<th>Mass of seeds/g</th>
<th>Mass of one seed/g</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Eight (one ASHTAK)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2.</td>
<td>Sixteen (Two ASHTAK)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3.</td>
<td>Any number of seeds picked up without counting (Random Number)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Teacher: Consult Table-2 prepared by you and answer the following questions:

1. What is the mass of one ASHTAK of *Moong Dal Seeds*?
2. What is the mass of 2 ASHTAKS of *Moong Dal Seeds*?
3. What is the mass of one ASHTAK of *Rajmah Seeds*?
4. What is the mass of one ASHTAK of *Chana Seeds*?
5. What is the mass of one ASHTAK *Urad Dal Seeds*?
6. Calculate each of the following:
   • Mass of 20 ASHTAK *Urad Dal Seeds* is ____________ g.
   • Mass of half ASHTAK *Rajmah Seeds* is ____________ g.
7. You know the average mass of one *Urad Dal* seed, how will you calculate the number of seeds in the randomly picked up sample of *Urad Dal* seeds?
8. You know the total mass of randomly picked up *Chana Seeds*. How will you find out number of ASHTAKS of *Chana Seeds* in the randomly picked up sample?

Teacher: You must have noticed the following points:

(i) Mass of one ASHTAK of different kind of seeds is different though the number of seeds in one ASHTAK of each type of seeds is same.

Note For The Teacher

Now teacher can ask the mass of one ASHTAK (eight) seeds of the kind chosen by the group and write it on the black board. Through questions, he/she can highlight that although each group has weighed eight seeds (identical number of objects) the mass of the one ASHTAK is different because mass of all seeds in a sample may not be same in each case. The discussion may proceed as given below.
(ii) Mass of two ASHTAKS of a substance is approximately twice the mass of its one ASHTAK and mass of three ASHTAKS of a substance is approximately thrice the mass of one ASHTAK of that substance and so on.

**Teacher:** Similarly mass of two moles of a substance will be twice the mass of one mole of that substance and mass of 2.5 moles of that substance will be 2.5 times the mass of one mole of that substance.

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### Activity 3

**Purpose of the activity:** To make students familiar with the term mass of one mole of a substance and help them to calculate the mass of one mole of a substance.

**Materials:** Provide one mole of each substance (Material may be chosen by the teacher) in separate containers.

**Initiation of activity through instructions:**
1. Record the name and formula of each substance in Table-3.
2. You have been provided 1 mol of each substance. Use balance to record mass of each substance.

### Table-3

<table>
<thead>
<tr>
<th>Name of the substance</th>
<th>Formula</th>
<th>Calculated formula mass</th>
<th>Mass of one mole of the given sample/g</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sodium chloride</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sodium nitrate</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Calcium sulphate</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Copper sulphate</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Note For The Teacher**

- Note that from tables given in the book, mass of one mole of atoms can be obtained. Therefore, formula mass calculated by using these tables gives us mass of one mole of substance.
- Discussion may proceed further through following questions.

### Questions

1. Compare the given mass of the substance and formula mass of the substance. What pattern do you observe?
2. If the formula mass of the substance is known, how can you predict the mass of 1 mol of the substance?
3. Write the steps for calculating the mass of 1 mol of a substance.
4. Predict the mass of 1 mol of each of the following substances:
   - (i) KCl
   - (ii) NaBr
   - (iii) HNO₃
   - (iv) H₂S
   - (v) ZnSO₄
5. Use the above rule to find the mass of each of the following substance:
   - (i) 3 mol CO₂
   - (ii) 5 mol Ca(OH)₂
   - (iii) 2 mol H₂S

### Enrichment for Teacher

- In a sample of a substance all the molecules may not have same mass because isotopes may be involved in the formation of some of the molecules. For example, all the molecules of CO₂ may not have same mass because different isotopes of carbon and oxygen may be forming the molecules.
Atomic mass of elements is measured relative to the mass of C-12 isotope of carbon. C-12 isotope is considered as a primary standard for measuring the mass of one atom of an element. Mass of one atom of this isotope is taken to be exactly 12 u.

One mole is the amount of a substance, which contains as many elementary entities (atoms, electrons, ions or molecules) as there are atoms in 12 grams of carbon-12.

The number of particles (atoms, molecules, ions, etc.) in a mole is fixed and is equal to $6.022 \times 10^{23}$. This is experimentally determined value. This number is called Avogadro constant or Avogadro number and is represented by $N_A$, named in the honour of Italian scientist, Amedeo Avogadro.

Historical perspective of Avogadro Number

Mass of Avogadro number of atoms can be calculated as follows:

- Mass of one electron = $9.1093897 \times 10^{-28}$ g
- Mass of one proton = $1.6726231 \times 10^{-24}$ g
- Mass of one neutron = $1.6749286 \times 10^{-24}$ g

For an element $^{m}_nX$:

The mass of the atom = Total mass of electrons + Total mass of protons + Total mass of neutrons

The mass of an atom = $n (9.1093897 \times 10^{-28}) + n(1.6726231 \times 10^{-24}) + (m-n)(1.6749286 \times 10^{-24})$

Thus mass of Avogadro number of atoms can be calculated by multiplying the above quantity by Avogadro number.

For example, if we want to calculate the mass of one mole of oxygen atoms, then we may proceed follows.

Number of protons in one oxygen atom = 8
Number of electrons in one oxygen atom = 8
Number of neutrons in oxygen = 16 - 8 = 8

Mass of one atom of oxygen = $8(9.1093879 \times 10^{-28}) + 8 (1.6726231 \times 10^{-24}) + 8(1.6749286 \times 10^{-24})$

$= (72.875103 \times 10^{-28}) + (13.380985 \times 10^{-24}) + (13.399429 \times 10^{-24})$

$= (72.875103 \times 10^{-4} + 13.380985 + 13.399429) \times 10^{-24}$

$= (0.007288 + 13.380985 + 13.399429) \times 10^{-24}$

$= 26.787702 \times 10^{-24}$ g

Therefore, mass of 1 mol (Avogadro number) of oxygen atoms can be calculated by multiplying the mass of 1 atom by Avogadro number.

$\therefore$ mass of 1 mol oxygen atoms = $(26.787702 \times 6.022) \times 10^{-4}$ g mol$^{-1}$

$= 161.316 \times 10^{-1}$ g mol$^{-1}$

$= 16.1316$ g mol$^{-1}$

When we use moles in calculations we abbreviate the units to mol. When we show the molar mass of the substance we show the units in g/mol or g mol$^{-1}$ (read as 'gram per mole')
• Mole is used –
  – as a convenient way to express the amounts of reagents and products of chemical reactions. For example, the reaction \( 2H_2 + O_2 \rightarrow 2H_2O \) implies that two moles of dihydrogen and one mole of dioxygen react to form two moles of water.
  – to express the number of atoms, ions or other elementary entities in some sample.
  – to express the concentration of a solution in the form of molarity i.e., the number of moles of the dissolved substance per litre of solution.
• Presently, one mole is taken as the number of molecules in 22.7 litre of ideal gas at STP or the number of atoms in 12 gram of carbon -12 isotope.
• Important relationships in mole concept:
  – 1 mol= \( 6.022 \times 10^{23} \) particles = Molar mass of the substance
  – One mole of atoms = \( 6.022 \times 10^{23} \) atoms = Gram atomic mass of element
  – Number of moles in the given mass of an element = \( \frac{\text{Given mass of the element}}{\text{Gram atomic mass of the element}} \)
  – Mass of one atom of an element = \( \frac{\text{Mass of one mole of an element}}{6.022 \times 10^{23}} \)
  – No of moles in the given mass of a compound = \( \frac{\text{Given mass of the compound}}{\text{Gram molecular mass of the compound}} \)
  – Mass of one mole molecules = \( \text{Mass of one molecule} \times 6.022 \times 10^{23} \)
  – Volume occupied by 1 mol mass of a gas at STP = 22.7 L
  – 22.7 L of a gas at STP contain \( 6.022 \times 10^{23} \) molecules

There is a misconception that mass of one mole of a substance depends only on its molecular formula. It should be clear that mass of the substance depends on the proportions of the isotopes of each element present in the sample. For example, one mole of calcium–40 is \( 39.96259098 \pm 0.00000022 \) grams, where as one mole of calcium-42 is \( 41.95861801 \pm 0.00000027 \) grams, and one mole of calcium with the normal isotopic mixture is \( 40.078 \pm 0.004 \) grams

**Assessment**

1. A copper piece is made up of \( 60.22 \times 10^{10} \) copper atoms. Calculate the moles of copper in it.

   **Solution:**
   
   Number of copper atoms = \( 60.22 \times 10^{10} \)

   \[
   \text{Moles of Copper} = \frac{\text{Number of atoms of copper}}{6.022 \times 10^{23}}
   \]

   = \( \frac{60.22 \times 10^{10}}{6.022 \times 10^{23}} \) mol

   = \( 1.0 \times 10^{-12} \) mol.
2. $18.066 \times 10^{22}$ molecules of CO$_2$ are equal to how many moles.

**Solution:** $6.022 \times 10^{23}$ molecules of CO$_2$ = 1 mol

Moles of CO$_2$ = $\frac{1 \times 18.066 \times 10^{22}}{6.022 \times 10^{23}}$

= $\frac{3}{10}$

= 0.3 mol.

3. Calculate the number of formula units in three moles of CaCO$_3$.

4. Calculate the mass of three moles of CaCO$_3$.

5. $12.044 \times 10^{23}$ water molecules are equivalent to how many moles?

6. Calculate the mass of $6.022 \times 10^{22}$ molecules of water.

7. Calculate the number of particles in 180 g of water.

8. Calculate the number of moles in 1000 g of CaCO$_3$.
This topic is very important from the point of view of learning chemistry. It is very important for the students to know the purpose that the periodic table serves. What makes each row and column of the Periodic Table so special, should be known to the students. It is very important to make the students realize that if they know the properties of an element what they can do with these properties. Students should be able to figure out what all the elements of a column have in common and how can they use that knowledge. Students should realize that the position of an element in the periodic table gives information about electronic configuration of the atom of that element. Learners should be introduced to the idea that reactivity of an element can be predicted if its position in the periodic table is known. Since the teaching – learning process of periodic table sometimes becomes boring, some strategies have been suggested for teaching this topic, which may make the topic interesting and enhance learning.

**Key Concepts**

- Periodic table is a method of organizing elements.
- Meaning of periodicity in properties of elements.
- Difference between a period and a group.
- Identification of common families of elements.
- Predicting the characteristics of elements knowing their position in the periodic table.
- Classification of elements as metals, non-metals and metalloids based on properties like ductility, malleability, conductivity of heat and electricity, luster, reactivity, etc.
- Relating reactivity of different elements to their atomic structures.
- Classification of elements in the modern periodic table is according to the atomic number of elements.
- Placement of isotopes in the modern periodic table.
- The position of an element in the modern periodic table helps to predict the electronic configuration of the element.

**Required Prior Knowledge**

Before learning about periodic table students should know—

- matter is made of tiny particles called atoms.
• atoms combine to form molecules.
• substances that contain only one kind of atoms are pure elements.
• symbols of elements, physical properties of metals and non-metals.
• about atomic number, atomic mass and electronic configuration.
• concept of isotopes and isobars.

Activity based teaching

Preparation required for teaching
Take 10 packets containing 25 items (5 sets of items of 5 types of things). For example: 5 paper circles of increasing diameter (0.5 - 2.5 cm), 5 squares of same colour but increasing side length (0.5 - 2.5 cm), 5 coins of circular shape and increasing size, 5 equilateral triangles of increasing size etc.). Remove any one item from all packets and let only 24 items remain in the packet. Make ten groups of students having 5 students each.

Materials required by each group of students
1. One plane paper sheet with a cage of 5 columns and 5 rows of squares (size 3 cm × 3 cm) marked on it.
2. Scale
3. Pencil
4. Eraser

This activity may be performed in the large class

Purpose of activity:
• This activity will cover the first five key concepts
• This activity can lead the students to –
  – understand the periodic law
  – the knowledge that period in the periodic table is horizontal row of elements.
  – understand that properties of elements vary gradually in the periods and rows
  – understand that properties of missing elements can be predicted by using the periodic table.
  – explain that pattern of gradation of properties is repeated in the rows and groups (Hence the name periodic table)
  – compare the Mendeleev’s periodic table and modern periodic table
  – relate the atomic structure and properties of elements of a group.
  – the solution of the problem of placing the isotopes in the periodic table.

Instructions to students
• Ask each group of students to collect one packet and instruct them to make the group of one type of items.
• Ask the students to identify the missing item.
• Now ask the students to spread the paper sheet on the table.
• Ask the students to arrange the items on the squares of the cage marked on sheet, according to their increasing or decreasing size.
• Ask the students to ensure that there is one item on one square and the square for the missing item is left free.
At this point explain that mendeleev used similar type of logic to predict the properties of missing elements.

Teacher can ask the students to measure the diameters of circles, height of triangle, length of side of square, etc. and ask the students to predict the dimensions of missing items.

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Teacher can ask the students to measure the diameters of circles, height of triangle, length of side of square, etc. and ask the students to predict the dimensions of missing items.

Purpose of the activity:
This activity will cover the following concepts

Mendeleev arranged the 63 elements known at that time according to the properties of elements.

Some gaps were left in the periodic table of elements not known at that time and Mendeleev could predict the properties of the missing elements.

Students will be able to compare the basis of classification of elements in Mendeleeev’s Periodic Table and Modern Periodic Table.

Preparation required before teaching

Mendeleeve’s Periodic Table and Modern Periodic Table of elements.

Divide the class in groups keeping in mind following categories of elements:

1. Alkali metals
2. Alkaline earth metals
3. Transition metals
4. Metalloids
5. Non metals
6. Halogens
7. Noble gases
8. Rare earth metals
9. Others (hydrogen)

Ask each group to collect the literature on group of elements assigned to them. The literature should be related to the following properties:

1. Lustre
2. Ductility
3. Malleability
4. Brittleness
5. Conductivity
6. Density
7. Melting point
8. State at room temperature (solid, liquid or gas)
9. Size of the atom
10. Number of protons in the nucleus (i.e. atomic number)
11. Number of isotopes found.
12. Electronic configurations of atoms.
13. Formula of oxides and hydrides for elements present in the Mendeleev’s periodic table.
14. Points of history such as, when was Mendeleev’s periodic table discovered? when was a particular element discovered? Who discovered the element? and so on.
15. Uses of various metals and non-metals in daily life.

**Initiating the activity**

Review of the following points before commencing the activity:

- An element has atoms which have the same electronic configuration.
- Atoms of elements may differ in the number of neutrons and hence can have different atomic mass (isotopes).
- Chemical properties of the elements are governed by the electronic configuration of the elements.
- Physical and chemical properties of metals, non-metals, and metalloids.

**Proceeding with the activity**

Distribute copies of periodic tables (Mendeleev’s and modern periodic) to the students and guide them to compare both the tables by asking questions as follows:

- Ask the students to search from the literature when was the Mendeleev’s periodic table discovered.
- Ask the students to compare the Mendeleev’s periodic table and modern periodic table and find out the difference in the organization of periods and rows in the tables.
- Tell the students about the basis of classification of elements in the Mendeleev’s periodic table.
- Explain the reason for the gaps in the Mendeleev’s Periodic Table.
- Help the students realize the way Mendeleev predicted the properties of the missing elements.
- Highlight the points due to which new efforts were made to classify the elements.
- What is the basis of classification of elements in the Modern Periodic Table?
- Provide the students blank Modern Periodic Table.
- Ask the students to arrange the elements in the periods of blank periodic table according to the atomic number.
- Ask whether they can find any similarity in the electronic configuration of elements present in the same column of the Modern Periodic Table.
- Ask them to search the literature collected by them to find out the location of various groups of elements in the Modern Periodic Table and locate it in the periodic table prepared by them.
- Help the students realize the gradation in various properties like metallic character, atomic radius, etc.
- Ask the students whether they can find out the number of electrons available in the atom of an element for bonding.
- Ask whether the problem of placement of isotopes has been solved in the Modern Periodic Table, etc.

**Enrichment for Teacher**

- The students start learning about the classification in very early stages, the teacher should know how to relate the new information with the concept already known to the students.
- As the topic is used at later stages of learning chemistry and it is frequently used for understanding the gradation in behaviour and reactivity of elements and their compounds, a firm foundation is required at this stage of learning. For example, if the teacher is teaching about the variation of reactivity of metals with water, he (she) should know that metal reacting with cold water is more active than the metal reacting with hot water and the metal reacting
with steam is less reactive than the metal reacting with hot water. Similarly the teacher should know when the reactivity with acid is being considered; the concentration and strength of the acid must be considered.

- Teacher should know about the other attempts of scientists to make periodic table and why those periodic tables are not in use. What problems are associated with the modern periodic table and what attempts have been made to solve these problems?

**Suggestions for Other Methods of Teaching**

If a good library or internet is available to the students or if the teacher can provide the learning material, project work can also help in teaching about periodic table. Learners may be asked to collect the data like atomic mass, atomic radius, metallic and non metallic character, etc. Teacher may ask the learners to make cards using the data collected by them. The teacher can then make them use these cards to learn about periodic table.

**Major Difficulties Faced by Learners are –**

- Remembering the periodic table
- Predicting the properties of the elements using the periodic table
- Using the periodic table.

To solve these problems several innovative methods can be designed. For example a play way method can be used for the learner to remember the names of elements and their symbols. Some examples are given below:

A. One can make a crossword puzzle based on names, symbols and properties, etc. One example is given below:

**Vertical:**

1. Silvery white metal used for making bridges (4 letters, Fe)
2. An inert gas (5 letters, Xe)
3. Liquid metal (7 letters, Hg)
4. Element whose deficiency causes goiter (6 letters, I)
5. A gas which burns with pop sound (8 letters, H)

**Horizontal:**

6. A gas important for survival of life on earth (6 letters, O)
7. An inert gas (5 letters, Ne)
8. Yellow coloured non-metal (8 letters, Cl)

B. Make cards of elements and write electronic configuration on them. Ask the students to write the symbol and name of the element on the card and place the card in the blank space given in the periodic table.

C. Quiz can be arranged

D. Give the blank space in the periodic table and ask the student to predict the properties of element that will come in the blank space.
For example

(i) A metal has atomic no 11. How many Electrons will be there in its K shell?

(ii) The above metal reacts with cold water, lot of heat is evolved and flames are seen. The metal disappears and the solution in water becomes alkaline. In which block of the periodic table will you keep it.

(iii) In which period and in which column will the above element be placed.

E. To check the interconnections formed between various concepts as received by the learner, concept map can be used, for example, one may give key words and statements like alkali metals, first group of elements; silver, gold, transition elements; sodium, find place in first column and second period, etc. The students may be asked to interconnect the words and relevant statements provided to them. This may also be a good assessment tool for the assessment of learner’s understanding and exploring the learner’s thinking.

F. Distribute some copies of blank periodic table to the students. Distribute the cards among the students in which properties of the elements are written. Each student should get at least four cards. Ask the students to paste the cards on proper place in the periodic table.

- Students may be assessed on the basis of the group activity followed by a quiz competition.
- Students may be divided into groups and each group may be assigned the task of preparing the chart showing the importance of the elements of a particular group. The group may be asked to make a presentation related to the group of element assigned to them and present it before the whole class. Each group may be asked to frame 5-10 quiz questions based on their presentation. These questions may be given to other groups in an open quiz after completion of all presentations.
- The teacher should provide the guiding points for preparing the poster. For example, teacher may tell that each poster should include the state of the element at room temperature, atomic number, atomic mass, electronic configuration of atom, the year of discovery, metal, non-metal or metalloid. Some interesting information about the particular group of elements assigned for presentation.
- The rules for evaluation may be told to the students. For example, students may be told that groups will receive common grade. Individual points may be gained by answering the quiz questions. Evaluation scheme for evaluating the poster should be disclosed.
- Students may be told that poster will be judged on the four point scale as follows:
1. Creativity and Quality

<table>
<thead>
<tr>
<th>Level</th>
<th>Score assigned on four point scale</th>
</tr>
</thead>
<tbody>
<tr>
<td>Level–1 Poster reflects beginning of understanding</td>
<td>1</td>
</tr>
<tr>
<td>Level–2 Poster reflects movement towards mastery of concepts</td>
<td>2</td>
</tr>
<tr>
<td>Level–3 Poster reflects mastery of concepts</td>
<td>3</td>
</tr>
<tr>
<td>Level–4 Poster reflects highest level of understanding</td>
<td>4</td>
</tr>
</tbody>
</table>

2. Quality of Test Questions (for quiz)

<table>
<thead>
<tr>
<th>Level</th>
<th>Score assigned on four point scale</th>
</tr>
</thead>
<tbody>
<tr>
<td>Level–1 Questions are not relevant</td>
<td>1</td>
</tr>
<tr>
<td>Level–2 Questions are poor in quality but are relevant</td>
<td>2</td>
</tr>
<tr>
<td>Level–3 Questions are relevant</td>
<td>3</td>
</tr>
<tr>
<td>Level–4 Questions are relevant and students apply general principles to answer</td>
<td>4</td>
</tr>
</tbody>
</table>

**MISCONCEPTIONS THAT NEED TO BE HANDLED**

- There is only one way to categorize the elements
- Every thing regarding the elements is known.
- The elements are arranged in the periodic table by mass. This problem can be easily solved if the student knows the difference between atomic number and atomic mass.
- The properties or characteristic do not vary uniformly to represent periodic variation. Pointing out the anomalies carefully can solve this problem

**ASSESSMENT**

Q1. Name the property which is used to arrange the elements in the Modern Periodic Table.

Q2. Which atomic particle is responsible for the arrangement of elements in the Periodic Table.

Q3. Consult the Mendeléev’s Periodic Table given in the textbook and write the formula of oxides of following elements:
   (i) Hydrogen    (ii) Carbon    (iii) Phosphorous    (iv) Sodium
   (v) Calcium     (vi) Aluminium.

Q4. Consult the Mendeléev’s Periodic Table given in the textbook and write the formula of hydrides of following elements:
   (i) Oxygen    (ii) Sodium    (iii) Aluminium    (iv) Carbon
   (v) Fluorine    (vi) Phosphorous.
INTRODUCTION

Students have already learnt about general characteristics of acids, bases and salts in their previous classes. They have also studied about the action of acids and bases on natural and man made indicators. This chapter presents overall view of important properties of acids, bases and salts in brief.

KEY CONCEPTS

- Indicators show different colours in acidic/basic medium.
- Acids and bases neutralize the effect of each other.
- Neutralization reaction
- Acids and bases dissociate into ions in water.
- Aqueous solutions of acids and bases conduct electricity.
- Difference between terms acidic properties and acids.
- Difference between terms basic properties and bases.
- Strength of acid/base
- Differentiation between strength of acid/base and concentration of acid/base.
- Acidic and basic nature of salts.
- Metal carbonates and metal hydrogen carbonates are salts but they react with acid.
- Oxides of metals and non-metals are not salts.
- Concept of pH

PRIOR KNOWLEDGE REQUIRED

- Acid-base indicators show different colours in acidic/basic medium
- Concept of electrical conduction

TRANSACTION STRATEGY

Demonstration or activity based teaching can be a good strategy for teaching acids, bases and salts. Following concepts can be taught by demonstration method.

- Acid and base indicators
- Neutralization reaction
• Acids and their reactions with metals
• Electrical conductivity of acids and bases

**Demonstration for acid base indicators**

Since students have already learnt about indicators, this concept should be **recapitulated** through demonstration.

**Preparation**

*Material required:* Test tubes, test tube stand, indicators, different acids and different bases, work-sheet.

**Classroom Interaction**

• Distribute the following work-sheet to the students which they will fill during demonstration.

**Work-sheet**

<table>
<thead>
<tr>
<th>Indicators</th>
<th>Colour Change</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Acid</td>
</tr>
<tr>
<td>Litmus paper</td>
<td>Blue</td>
</tr>
<tr>
<td></td>
<td>Red</td>
</tr>
<tr>
<td>China Rose extract</td>
<td></td>
</tr>
<tr>
<td>Methyl orange</td>
<td></td>
</tr>
<tr>
<td>Phenolphthalein</td>
<td></td>
</tr>
</tbody>
</table>

• Arrange the solutions of different acids and bases in the test tube stands.
• Tell the students about the activity and ask them to fill the table in the given work sheet.
• Ask the students to give general statements about the colour change of indicators with acids and bases on the basis of their observations.

**Activity to show acidic / basic property of salts**

Students may be asked to perform the test with the aqueous solution of ammonium chloride, copper sulphate, calcium carbonate, sodium chloride, etc. using universal indicator.

**Activity to show role of water in dissociation of Acid, Base & Salt**

The activity 2.9 of the NCERT Class 9 textbook explains the role of water. In this activity HCl gas is produced by reacting solid NaCl with concentrated sulphuric acid. The gas is dried by passing through a tube containing solid calcium chloride and tested with dry and moist litmus paper separately. Activity 2.9 may also be performed with ammonia gas. The ammonia gas can be prepared by heating ammonium chloride with sodium hydroxide in a test tube. Test the gas evolved successively with dry and wet litmus paper

*(Note: Even the dry litmus paper may show a colour change in the damp weather)*
Difference between the terms **Acidic properties and Acids**

Acids are substances which change the colour of blue litmus to red. Sometimes, it leads to a misconception that all substances which change the colour of blue litmus to red are acids. For example, ammonium, sulphate, ammonium chloride, etc. are not acids but their aqueous solution change the colour of blue litmus to red. Such substances possess acidic property.

**Difference between the terms Basic properties and bases**

Substances like sodium hydroxide, potassium hydroxides, are considered as bases. The difference between bases and basic properties may be explained by taking the example of some salts like sodium acetate. Solution of sodium acetate, changes colour of red litmus to blue but the compound is not base, rather it possesses basic properties.

**Concept of strength of an acid / base**

In general, acids are substances that produce hydronium ion (H$_3$O$^+$) by reaction with water. For example, hydrogen chloride is a covalent molecule but when it is dissolved in water it reacts with it and produces H$_3$O$^+$ ions.

\[
\text{HCl} + \text{H}_2\text{O} \rightarrow \text{H}_3\text{O}^+(aq.) + \text{Cl}^-(aq.)
\]

Aqueous solution of hydrogen chloride is called hydrochloric acid. Hydrogen chloride is a strong electrolyte because its dissociation in water is complete. This means that 1 mol of hydrogen chloride produces 1mol of H$_3$O$^+$ ions and 1mol of Cl$^-$ ions. Hydrochloric acid is a strong acid.

There are many acids which are weak electrolytes. One of the example is acetic acid. It reacts with water according to following equation.

\[
\text{CH}_3\text{COOH} (l) + \text{H}_2\text{O} \rightarrow \text{H}_3\text{O}^+(aq.) + \text{CH}_3\text{COO}^-(aq)
\]

It should be noted that in the above reaction only a fraction of solute dissociates into ions, which means the concentration of hydronium ions in solution is low. This is the reason that acetic acid and other acids that are weak electrolytes are called weak acids. This means that if we take 1mol hydrochloric acid and 1mol acetic acid separately in same amount of water then more hydronium ions will be present in the solution of hydrochloric acid than in the solution of acetic acid.

Although many acids contain hydrogen, but there are many other substances that do not contain hydrogen, yet they produce acidic solutions when dissolved in water. A common example is carbon dioxide. It dissolves in water to produce carbonic acid as follows:

\[
\text{CO}_2 + \text{H}_2\text{O} \rightarrow \text{H}_2\text{CO}_3
\]

This acid is responsible for the formation of large limestone caverns that exist all over the world. Ground water becomes acidic due to dissolution of carbon dioxide from the atmosphere. This acidic water tickles down through the limestone (CaCO$_3$) and reacts with it forming calcium hydrogen carbonate which is soluble in water and flows away with water leaving huge caverns behind.
CaCO$_3$(s) + H$_2$CO$_3$(aq.) → Ca$^{2+}$ + 2HCO$_3^-$ (aq.)

Both HCl and acetic acid are able to furnish only one hydrogen ion per molecule. Such acids are also called monoprotic acids. There are many acids which are able to furnish more than one hydrogen ion per molecule of the acid for the reactions. For example sulphuric acid furnishes two hydrogen ions and is called diprotic acid. This happens in two distinct steps.

\[ H_2SO_4 + H_2O \rightarrow H_3O^+(aq) + HSO_4^-(aq) \]
\[ HSO_4^-(aq.) + H_2O \rightarrow H_3O^+(aq) + SO_4^{2-} \]

Similarly, phosphoric acid dissociates in three distinct steps and is called a triprotic acid.

\[ H_3PO_4 + H_2O \rightarrow H_3O^+(aq) + H_2PO_4^-(aq) \]
\[ H_2PO_4^-(aq) + H_2O \rightarrow H_3O^+(aq) + HPO_4^{2-} (aq) \]
\[ HPO_4^{2-} (aq) + H_2O \rightarrow H_3O^+(aq) + PO_4^{3-} (aq) \]

In fact, in the second step only 10% sulphuric acid is dissociated. Even then sulphuric acid is called strong acid, because the first dissociation is complete. Phosphoric acid on the other hand is a weak acid because all the steps of dissociation are equilibrium steps and do not proceed very far towards completion.

**Salts formed after neutralization reaction may not form neutral aqueous solutions**

We know that reaction between an acid and a base to form salt and water is known as neutralization reaction.

Base + Acid → Salt + Water

In this reaction the acid and base neutralize the effect of each other. The nature of product (salt) formed as a result of neutralization reaction is considered as neutral. But the salt formed as a result of neutralization reaction between strong acid with weak base exhibits acidic property in aqueous solution and the salt obtained from neutralization reaction between weak acid and strong base exhibits basic property in aqueous solution due to the hydrolysis of these salts in water.

It should be noted that although dissociation of weak acid /weak base attains equilibrium and dissociation never reaches completion, the neutralization reaction between an acid and a base always reaches completion and the reaction mixture is neutral at the exact neutralization point. As soon as hydrogen ions are removed from the solution of a weak acid due to combination with hydroxyl ions, the equilibrium between the ions of the acid and unionized form of the acid is disturbed. To attain the equilibrium again, more acid ionizes and the process continues till whole amount of the acid is neutralized by base. The salt formed as a result of neutralization of acid and base is also neutral. Therefore using the terms like acid salt or basic salt creates confusion. It should be very clear that salts are never acidic or basic. Solutions formed by some salts in water may be acidic or basic due to reaction of the salt with water (i.e. hydrolysis of salt).

**Role of Water in Dissociation of Acid, Bases and Salts**
Water is a polar solvent. The high dielectric constant of water molecules weakens the forces of attraction between the oppositely charged ions of the ionic lattice and its polar nature generates ion-dipole interactions in which the cation is attacked by the negative end of the water dipole, whereas the anion is attacked by the positive end of water dipole. The consequence of this is that the ions are pulled into solution and become hydrated. Certain covalent molecules like HCl can also dissolve and dissociate in water to produce an ionic solution because of stronger ion–dipole interaction.

**The dissociation of water**

Even the purest water has a very minute value of electrical conductivity. This is the evidence that water forms ions, i.e.

Generally, the dissociation of water is represented by the following equation:

$$\text{H}_2\text{O} \rightarrow \text{H}^+(aq) + \text{OH}^-(aq)$$

Here, $\text{H}^+$ is called hydrogen ion. However, $\text{H}^+$ cannot exist in water as such. It gets associated with water molecules forming hydronium ion ($\text{H}_3\text{O}^+$)

$$\text{H}^+(aq) + \text{H}_2\text{O} \rightarrow \text{H}_3\text{O}^+(aq)$$

Therefore, whenever an acid dissociates in water it produces hydrogen ion which exists as hydronium ion.

The equilibrium constant in this reaction lies far to the left. It can be written as follows:

$$K_e = \frac{[\text{H}^+][\text{OH}^-]}{[\text{H}_2\text{O}]}$$

Since there is very minute amount of ions present, the concentration of water will practically remain constant. Thus we can introduce a new constant in place of $K_e \times [\text{H}_2\text{O}]$. This overall constant for water is written as $K_w$

$$K_w = [\text{H}^+][\text{OH}^-]$$

At 25°C, $K_w = 1 \times 10^{-14}$

It should be noted that if we increase the concentration of hydrogen ion by adding acid to water, the concentration of OH− ions will decrease so that value of $K_w$ remains constant. On the other hand if we increase the concentration of OH− ions by adding base, then the concentration of H+ ions will decrease.

**The pH Scale**

The pH scale was introduced by the Danish biochemist S.P. Sorensen in 1909 while working on quality control in the brewing of beer and is now widely used. As defined by him, the pH of solution is the negative logarithm (to the base 10) of concentration (in moles per liter) of hydrogen ions present in it.
pH = -log [H⁺] = - log [H₂O⁺]

The molarity of hydronium ion may vary in a very long range. In some solutions it may be higher than 1 mol/L and in other solutions it may be lower than 10⁻¹⁴ mol/L. Taking the logarithm it condenses the scale to a much smaller and convenient scale called pH scale. That is why chemists prefer this scale. At 25°C (297K) in pure water concentration of hydrogen ions is equal to the concentration of hydroxyl ions. This may be represented as:

H₂O ⇌ H⁺(aq) + OH⁻(aq)

The ionic product of H₂O, K_w at 25°C (297K) is 1 × 10⁻¹⁴. Since the molar concentration of H⁺(aq.) ion and OH⁻(aq) ion are same:

[H⁺] = [OH⁻] = 1 × 10⁻⁷ at 25°C

Thus, pure distilled water has [H⁺] = 1 × 10⁻⁷ hence, its pH is 7. The pH of a neutral solution is 7 at 25°C. Solutions with pH value less than 7 have more H⁺(aq) ions than 1 × 10⁻⁷. It means H⁺(aq) ion concentration would have less negative power of 10, may be 10⁻⁵ or 10⁻⁴(aq) or the pH 5 or 4, respectively. Most of the solutions have pH ranging between values 0 to 14.

It is very important to note that value of dissociation constant of pure water depends on temperature (Table-1). This means that hydrogen ion concentration in neutral water will be different at different temperatures. Thus, pH of pure distilled water will also be different at different temperature.

Important points that should be taken care of during discussion of reactivity of metals with acids and bases.

While discussing the reaction of metals with acid and bases one should not guarantee that all metals displace hydrogen from acids. Metals less reactive than hydrogen like copper do not show this reaction. More over behaviour of nitric acid is also different. Besides being an acid it is also a strong oxidizing agent. Active metals displace hydrogen from the nitric acid but since it is a strong oxidizing agent and hydrogen is a reducing agent, secondary reaction takes place resulting in the reaction of nitric acid to give oxides of nitrogen, NO, N₂O, or NO₂ depending on the nature of metals, concentration of acid and temperature. Few reactions of nitric acid and with copper and zinc are as follows:

Cu + 4HNO₃ (Conc.) → Cu(NO₃)₂ + 2NO₂ +2H₂O
3Cu + 8HNO₃ (Dil.) → 3Cu(NO₃)₂ +2NO +4H₂O
4Zn + 10 HNO₃ (Dil.) → 4Zn(NO₃)₂ + N₂O + 5H₂O
4Zn +10 HNO₃ (Very Dil.) → 4Zn(NO₃)₂ + NH₄NO₃ + 3H₂O

It should be kept in mind that all the metals do not give hydrogen with sodium hydroxide.

<table>
<thead>
<tr>
<th>Temperature / °C</th>
<th>K_w</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0.11 × 10⁻¹⁴</td>
</tr>
<tr>
<td>20</td>
<td>0.68 × 10⁻¹⁴</td>
</tr>
<tr>
<td>25</td>
<td>1.0 × 10⁻¹⁴</td>
</tr>
<tr>
<td>50</td>
<td>5.47 × 10⁻¹⁴</td>
</tr>
<tr>
<td>100</td>
<td>51.3 × 10⁻¹⁴</td>
</tr>
</tbody>
</table>

Table-1: Dissociation constant of pure water at different temperatures
Salts formed by neutralization reaction with strong acid and weak base or strong base and weak acid are not neutral in nature.

Neutralization reaction between strong acid/base and weak base/acid is never complete.

**Assessment**

Various tests were carried out with compounds A to E in a laboratory. Results of the tests are tabulated in the table given below. On the basis of these observations identify the compounds A to E amongst HCl, HNO₃, NaOH, NaHCO₃, and NaCl and also write the reactions envolved.

<table>
<thead>
<tr>
<th>Substance</th>
<th>Colour with Litmus</th>
<th>Reaction with NaHCO₃</th>
<th>Universal Indicator</th>
<th>Addition of HCl</th>
<th>Addition of Zn</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>Blue litmus turns red</td>
<td>Gas is formed</td>
<td>Red</td>
<td>No reactions</td>
<td>Gas is formed</td>
</tr>
<tr>
<td>B</td>
<td>Blue litmus turns red</td>
<td>Gas is formed</td>
<td>Red</td>
<td>No reaction</td>
<td>Brown coloured gas is formed</td>
</tr>
<tr>
<td>C</td>
<td>Red litmus turns blue</td>
<td>No reaction</td>
<td>Dark blue</td>
<td>No reaction</td>
<td>Gas is formed on heating</td>
</tr>
<tr>
<td>D</td>
<td>Red litmus turns blue</td>
<td>No reaction</td>
<td>Blue</td>
<td>Gas is formed</td>
<td>No reaction</td>
</tr>
<tr>
<td>E</td>
<td>No action with litmus</td>
<td>No reaction</td>
<td>Light green</td>
<td>No reaction</td>
<td>No reaction</td>
</tr>
</tbody>
</table>

**Answers**

A = HCl
B = HNO₃
C = NaOH
D = Na₂CO₃
E = NaCl
Carbon is the seventh most abundant element by weight in the earth’s crust. It occurs in the native state in the form of coal, diamond and graphite. In the combined state it occurs as carbonates, hydrocarbons, etc. It is also the essential constituent of all living organisms.

It is important to note that carbon has been chosen by the scientists as standard to compare the atomic mass of elements. It is a specific element which forms a large number of compounds. Importance and scope of its compounds are so wide that these are studied in a separate branch of chemistry called organic chemistry. At Secondary Stage formation of foundation of organic chemistry starts. Therefore, it is very important to introduce students with the specific properties of this element at this stage.

• Carbon can not lose four electrons to form C$^{4+}$ ions.
• Carbon can not gain four electrons to form C$^{4-}$ ions.
• Carbon shares four electrons with the atoms of other elements to form four bonds.
• Bond formed by sharing of electrons is called covalent bond. Sharing of electrons can be from both the atoms or the shared pair is donated by one atom only.
• catenation is the specific property of carbon due to which it forms long chain and cyclic compounds.
• Carbon can form multiple bonds with other carbon atoms and with the atoms of other elements.
• Double bond and triple bond.
• Saturated compounds and unsaturated compounds.
• Chain compounds and cyclic compounds.
• Formulae and structures of saturated and unsaturated compounds.
• Functional group – meaning and identification.
• Homologous series.
• Nomenclature of carbon compounds.
• Chemical properties of carbon compounds.
• Important carbon compounds – ethanol, methanol and ethanoic acid.
Before learning about this topic student should be familiar with –
- symbols of elements,
- valence of different elements,
- electronic configuration of atoms,
- concept of chemical bond formation,
- writing formulae of compounds,
- concept of chemical reaction,
- methods of balancing chemical equations.

Why is carbon a very special element and forms a large number of compounds?
- Carbon has small atomic size.
- Carbon has high electronegativity value (2.5).
- Carbon has high ionization enthalpy.
- It should be noted that carbon is in the centre of the second row of elements in the periodic table (Table-1).

The atoms to the left of carbon have the tendency to give up electrons, whereas the atoms to the right have tendency to gain electrons. Carbon is in the middle. It neither gives nor takes electrons easily. It shares electrons with other carbon atoms and with the atoms of other elements. Bond energy of single bond between the atoms of same element decreases steeply as we move in the period from carbon to fluorine. It can be seen from the bond energy of C-C, N-N, O-O, and F-F bond in ethane, hydrazine, hydrogen peroxide and fluorine molecules respectively, as given in Table -2.

<table>
<thead>
<tr>
<th>Bond</th>
<th>C–C</th>
<th>N–N</th>
<th>O–O</th>
<th>F–F</th>
</tr>
</thead>
<tbody>
<tr>
<td>Molecule</td>
<td>CH₃CH₃</td>
<td>H₂N–NH₂</td>
<td>HO–OH</td>
<td>F₂</td>
</tr>
<tr>
<td>Bond energy* (kJ/mol)</td>
<td>378</td>
<td>250</td>
<td>210</td>
<td>155</td>
</tr>
</tbody>
</table>
This is due to repulsion between non bonding electron pairs present on nitrogen, oxygen and fluorine atoms. We may expect that nitrogen atoms may join together to form chains of nearly the same size as that of carbon, but this chain will be destabilized by the electrostatic repulsion of electron pairs on nitrogen atoms. The compounds with two or three nitrogen atoms containing N-N bond are rare and unstable. Similarly, compounds of oxygen containing more than two atoms of oxygen linked by O-O bond are rare and unstable. The molecules containing C-C bonds are most varied. These may be linear, branched or cyclic. Instead of forming diatomic molecules like O\(_2\), N\(_2\) and F\(_2\), carbon prefers to form polymeric structures. Average bond energies of double and triple bonds between two atoms of same element are given in the Table-3.

The bond energy data of Table-3 shows that bond energy of one double between two carbon atoms is less than the bond energy of two single bonds in a chain. Therefore carbon-carbon chain is more stable than the double bonded carbon.

\[
\text{C} = \text{C} \quad \text{C} - \text{C} - \text{C} \\
611 \text{ kJ/mol} \quad 374 \text{ kJ/mol} + 374 \text{kJ/mol} = 748 \text{kJ/mol.}
\]

On the other hand multiple bonds of diatomic molecules O\(_2\) and N\(_2\) are much stronger than the single bonds of homochains as can be seen from the following data.

\[
\text{O} \equiv \text{O} \quad \text{O} - \text{O} - \text{O} \\
498 \text{ kJ/mol} \quad 210 \text{ kJ/mol} + 210 \text{ kJ/mol} = 420 \text{ kJ/mol} \\
\text{N} \equiv \text{N} \quad \text{N} - \text{N} - \text{N} - \text{N} \\
946 \text{ kJ/mol} \quad 250 \text{kJ/mol} + 250 \text{kJ/mol} + 250 \text{kJ/mol} \\
\quad = 750 \text{ kJ/mol}
\]

The uniqueness of carbon in forming long chains seems surprising at first sight because silicon, which lies below carbon in the periodic table and has similar electronic configuration as carbon, does not form stable silicon chains. The reason is that C-C bond is much stronger than the Si-Si bond (average bond energy210 - 250 kJ/mol). Therefore, Si-Si bond is weak enough to be broken. Also, due to larger size of silicon atom, the Si-Si bond length is larger than C-C bond length. Therefore electrostatic
forces holding the atoms together are correspondingly weaker. Similar is the case with other elements. As can be seen from the Table -4, the average bond dissociation energy of element – element bond decreases as we move down the group. Hence, strength of single bond between two atoms of the same element also decreases as we go down the group.

Carbon forms a very large number of compounds which has been classified in various categories. These includes series of compounds knows as homologous series. The concept of homologous series may be transacted through activities. One example is given here.

### Homologous Series

**Table-4: Average bond energies of single bonds between atoms of same element**

<table>
<thead>
<tr>
<th>Element-Element Single Bond</th>
<th>Average Bond Energies (kJ/mol)</th>
</tr>
</thead>
<tbody>
<tr>
<td>C-C</td>
<td>356</td>
</tr>
<tr>
<td>Si-Si</td>
<td>210-250</td>
</tr>
<tr>
<td>Ge-Ge</td>
<td>190-210</td>
</tr>
<tr>
<td>Sn-Sn</td>
<td>105-145</td>
</tr>
</tbody>
</table>

#### Activity 1

**Material required:** small cards, marker/coloured pen

**Preparation of Activity**

Prepare small cards having formula of some organic compounds. Out of these compounds some of them will be member of one or two homologous series. Remember some of the cards have formula of compounds that do not belong to homologous series.

You can prepare such sets of cards according to need of the class.

**Procedure:**

- Display the following properties of homologues series in the class.
- Make group of students according to set of cards available.
- Distribute one set of cards to each group.
- Ask them to make a homologous series from the formula written on the card.
- Let each group present the homologous series and let other group give their views.

Teacher will facilitate the discussion and will provide appropriate inputs.

**Nomenclature of organic compounds**

Nomenclature implies assigning proper name to a particular compound on the basis of certain rules so that the study of these compounds may become systematic. Two systems of naming organic compounds are generally used.

1. **Trivial System**

In earlier days organic compounds were named after the source from which they were obtained. For example, urea got its name because the compound was obtained from urine of mammals. Similarly, methyl alcohol was called wood sprit since it could be obtained as one of the products during the destructive distillation of wood. Formic acid derived its name from Greek word formicus (red ants), since acid could be obtained
from red ants. These names are without any systematic basis and are known as common names or trivial names. Such a system of nomenclature is known as trivial system. The common names of some organic compounds are given in Table -5.

2. IUPAC System

History

An International Congress of Chemists was held in Geneva in 1892 to rationalize the system of naming organic compounds. This system of nomenclature was named as Geneva System. Since then the system of naming has been improved from time to time by the International Union of Pure and Applied Chemistry (IUPAC). This system of Nomenclature was first introduced in 1947. The most exhaustive rules of nomenclature were first published in 1979 and later revised and updated in 1993. IUPAC nomenclature has been further revised and the draft version of 2004 is available on web.

Naming the Compounds

According to IUPAC system, the name of an organic compound consists of three parts

(i) Word root  
(ii) Suffix  
(iii) Prefix

(i) Word Root: The word root denotes the number of carbon atoms present in the chain. For chains containing one to four carbon atoms, word roots are derived from common names of compounds and for 5 carbon atoms onwards, it is derived from the latin name of that number. (Table-6)

Table -6: Word root for carbon chains of 1-10 carbon atoms.

<table>
<thead>
<tr>
<th>Chain Length</th>
<th>Word Root</th>
<th>Chain Length</th>
<th>Word Root</th>
</tr>
</thead>
<tbody>
<tr>
<td>One carbon</td>
<td>Meth</td>
<td>Six carbon</td>
<td>Hex</td>
</tr>
<tr>
<td>Two carbon</td>
<td>Eth</td>
<td>Seven carbon</td>
<td>Hept</td>
</tr>
<tr>
<td>Three carbon</td>
<td>Prop</td>
<td>Eight carbon</td>
<td>Oct</td>
</tr>
<tr>
<td>Four carbon</td>
<td>But</td>
<td>Nine carbon</td>
<td>Non</td>
</tr>
<tr>
<td>Five carbon</td>
<td>Pent</td>
<td>Ten carbon</td>
<td>Dec</td>
</tr>
</tbody>
</table>

(ii) Suffix: The word root is linked to a suffix which may be primary or secondary or both.

(a) Primary Suffix - It indicates the nature of linkage in the carbon atoms. For example, if carbon atoms are linked with a single covalent bond (C-C), the primary suffix ane is used. For double and triple bonds between two carbon atoms, the primary suffixes ene and yne are used, respectively.

- ane - for C-C (single bond) compounds
- ene - for C=C (double bond) compounds
- yne - for C≡C (triple bond) compounds
(b) **Secondary Suffix** – It indicates the presence of functional group in the organic compound. Some common secondary suffixes used to represent functional groups are shown in Table-7.

Table-7: Secondary suffixes and functional groups for some classes of compounds

<table>
<thead>
<tr>
<th>Organic Compound</th>
<th>Secondary Suffix</th>
<th>Functional Group</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alcohol</td>
<td>- ol</td>
<td>-OH</td>
</tr>
<tr>
<td>Aldehyde</td>
<td>- al</td>
<td>-CHO</td>
</tr>
<tr>
<td>Ketone</td>
<td>-one</td>
<td>&gt;C=O</td>
</tr>
<tr>
<td>Carboxylic acid</td>
<td>-oic acid</td>
<td>-COOH</td>
</tr>
<tr>
<td>Ester</td>
<td>-oate</td>
<td>-COOR</td>
</tr>
<tr>
<td>Amine</td>
<td>-amine</td>
<td>-NH₂</td>
</tr>
</tbody>
</table>

(iii) **Prefix:** There are many groups which are not regarded as functional group in the IUPAC nomenclature of the compounds. These are regarded as substituent or side chains. These are represented as prefixes and are placed before the word root while naming the organic compound. For example:

– CH₃ (methyl) group, – CH₂CH₃ (ethyl) group

However, some functional groups are also represented as prefix only. For example, –F (fluoro), – Cl (chloro), – Br (bromo), –I (iodo) and –NO₂ (nitro).

If a compound contains more than one functional groups, then one of the functional groups is regarded as principal functional group and is treated as secondary suffix. The other functional groups are regarded as substituents and are indicated by prefixes.

Thus, a complete IUPAC name of organic compound can be represented as

Prefix + word root + primary suffix + secondary suffix

Remember: It may be noted that while adding the secondary suffix to the primary suffix, ‘e’ in the end of primary suffix (i.e., ane, ene, yne) is dropped if the secondary suffix begins with a vowel (a, e, i, o, u) However, the terminal ‘e’ is retained if the secondary suffix begins with a consonant.

Let us see how the word root is named:

While naming the word root, always select the longest continuous chain of carbon atoms in the molecule. It may be noted that longest chain may or may not be straight but it must be continuous. For example:

\[
\text{CH}_3
\]

\[
\text{CH}_3-\text{CH}-\text{CH}_2-\text{CH}_2-\text{CH}_2-\text{CH}-\text{CH}_2-\text{CH}_2-\text{CH}_3
\]

1 2 3 4 5 6 7 8 9

\[
\text{CH}_2\text{CH}_3
\]

Correct chain (contains 9 carbon atoms)
Incorrect chain (contains 8 carbon atoms)

If there is branching due to the substitution of alkyl groups the numbering is done in such a way that the branched carbon atoms get the lowest possible numbers. For example -

Correct numbering

Incorrect numbering

If a functional group is present then the longest chain containing functional group is selected as parent chain, although there may be other longer chain possible without the functional group.

Let us name some organic compounds:

1. \( \text{CH}_3 \text{CH}_2 \text{CH}_2 \text{CH}_2 \text{CH}_2 \text{OH} \)

Select the longest chain of carbon atoms bearing the functional group so that the functional group gets the lowest number.
Word root: But
Primary suffix: ane
Secondary suffix: ol
IUPAC Name: But + ane + ol drop the e of ane since secondary suffix begins with a vowel (o)
    Butan -1-ol    (correct)
    Butane -1-ol   (incorrect)

2. \(\text{CH}_3 - \text{CH}_2 - \text{CH} - \text{CH}_2\)

\[\begin{array}{cccc}
4 & 3 & 2 & 1 \\
\text{CH}_3 & \text{CH}_2 & \text{CH} & \text{CH}_2 \\
\end{array}\]

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>OH</td>
<td>OH</td>
</tr>
</tbody>
</table>

Word root: But
Primary suffix: ane
Secondary suffix: diol (There are two –OH functional groups)
IUPAC Name: Butane -1,2 - diol (correct)
    Butan -1,2 - diol (incorrect)
In this case ‘e’ from ‘ane’ has not been dropped, since diol is the secondary suffix and does not begin with a vowel.

3. \(\text{CH}_3\)

\[\begin{array}{c}
1 \quad 2 | \quad 3 \\
\text{CH}_3 - \text{C} - \text{CH}_3 \\
\end{array}\]

\[\begin{array}{c}
| \\
\text{CH}_3 \\
\end{array}\]

IUPAC Name: 2,2- Dimethylpropane

\[\begin{array}{cccc}
5 & 4 & 3 & 2 | 1 \\
\text{CH}_3 & \text{CH} - \text{CH}_2 - \text{C} - \text{CH}_3 \\
\end{array}\]

\[\begin{array}{c}
| \quad | \\
\text{CH}_3 & \text{CH}_3 \\
\end{array}\]

IUPAC Name: 2,2,4-Trimethylpentane

Detergent is the common term used for the cleansing agents, which includes both soaps and synthetic detergents. Generally people use the term detergent for the synthetic detergents only though soaps are also detergents.
Soaps

Soaps are sodium or potassium salts of higher fatty acids such as oleic acid \((C_{18}H_{33}COOH)\), stearic acid \((C_{17}H_{35}COOH)\), palmitic acid \((C_{15}H_{31}COOH)\), etc. These acids are present in the form of esters of glycerol, an alcohol containing three hydroxyl groups. These esters, called ‘glycerides’, are fats and oils of animals and vegetable origin.

**Preparation of soap**

When an oil or a fat (glyceride) is treated with sodium hydroxide solution, it gets converted into sodium salt of the acid (soap) and glycerol. The reaction is known as saponification.

\[
\begin{align*}
\text{CH}_2 - \text{O} - \text{C}_1\text{7H}_{35} & \quad \text{CH}_2\text{OH} \\
\text{CH} - \text{O} - \text{COC}_1\text{7H}_{35} \quad + 3\text{NaOH} & \rightarrow \quad \text{CHOH} \quad + \quad 3 \text{C}_1\text{7H}_{35}\text{COONa} \\
\text{CH}_2 - \text{O} - \text{COC}_1\text{7H}_{35} & \quad \text{CH}_2\text{OH} \\
\text{Glyceride} & \quad \text{Glycerol}
\end{align*}
\]

Some other additives like perfumes, disinfectants and medicines are added to the soap to give it the desired characteristics. Glycerol is a by-product of this reaction in soap industry. This useful chemical is isolated, purified and marketed.

Chemically, synthetic detergents are sodium salts of sulphonic acids, i.e., detergents contain a sulphonic acid group \((-\text{SO}_3\text{H})\), instead of carboxylic acid group \((-\text{COOH})\) as in soaps, on one end of the hydrocarbon chain.

**Soap molecule**

\[
\text{SO}_3\text{Na}^+ \quad \text{COO} \quad \text{Na}^+
\]

**Synthetic detergent molecule**

\[
\text{SO}_3\text{Na}^+ \quad \text{COO} \quad \text{Na}^+
\]

The cleansing action of a detergent in hard water is more efficient than soap. This is because a detergent does not get precipitated with metal ions such as Ca\(^{2+}\) and Mg\(^{2+}\). On the other hand, soap forms precipitate with these ions and, thus, becomes ineffective. Therefore, soaps are not effective cleansing agents in hard water.

---

**Activity 2**

- Take about 25 mL of caster oil (triglyceride) in a 250 mL beaker.
- Prepare about 50 mL 20% solution of sodium hydroxide in distilled water and add 30 mL of this solution in 25 mL caster oil and boil for about 40 minutes.
- Successively dip the red and blue litmus paper strips into this reaction mixture. Do you find any change in colour of any litmus paper strip? Note and record your observations.
- Add 5 g of common salt to this mixture and stir the mixture continuously with the help of a glass rod till the soap begins to set.
- Leave it for a day till the mixture cools and becomes solid.
- Remove the soap cake and cut it into desired shape and size.
While discussing chapter “Carbon and its Compounds”, a teacher should discuss the environmental issues related to the subject matter. For example:

(i) Harmful Effects of Drinking Alcohol
Ethanol, usually referred to as alcohol, is the only alcohol used for drinking, in spite of its many harmful effects. Other alcohols, namely, methanol or propan-1-ol are much more harmful than ethanol. For example, methanol (CH$_3$OH) when consumed even in small quantities causes serious poisoning accompanied by loss of eye sight. Methanol is oxidized to methanal in the liver. Methanal reacts rapidly with components of cells. It coagulates the protoplasm in the same way as an egg is coagulated by cooking. If a person drinks alcohol regularly even in small doses, he/she becomes dependent on it. This person loses all senses of discrimination under its influence. Consumption in large quantities may even cause death by damaging liver. Therefore, we should all condemn drinking of alcohol.

(Rather than telling these to students teacher can invite student’s opinions on this issue and give them opportunity to conclude without passing any judgment from his/her own side.)

(ii) Combustion
Combustion of fossil fuels, results in the formation of oxides of carbon, sulphur and nitrogen, which are major pollutants in the environment. Some of the pollutants formed are carcinogenic i.e., they cause cancer. They also harm plants by causing aging, breakdown of tissues and shedding of leaves, flowers, and twigs.

(iii) Water pollution
We all know, water is essential for life. Without water there would be no life. We usually take water as granted for its purity, but we must ensure the quality of water.

In past, widespread use of detergents caused pollution of river water and other water bodies. The long carbon chain present in detergents discussed earlier, contained a great deal of branching. These branched chain detergent molecules are degraded (breaking into smaller molecules) very slowly by the microorganisms present in sewage discharge septic tanks and water bodies with the result, the detergents persist in water for longer time and make water unfit for aquatic life.

Now-a – days, detergents used are made up of molecules in which the branching is minimum. These are degraded more easily than branched chain detergents.

(iv) Alcohol as a fuel
Sugarcane plants are one of the most efficient converters of sunlight into chemical energy. After removal of sugar crystals from sugarcane juice a dark coloured liquid is left which is called molasses. Alcohol(ethanol) is obtained by fermentation of molasses. Some countries now use alcohol as an additive in petrol since it significantly reduces emissions.
Assessment of learners by various methods in different situations helps in recognizing abilities of the learners. The teacher may choose one or more of the following methods of assessment during teaching–learning process, for example -

- Activities
- Demonstrations
- Projects
- Science quizzes/Puzzles
- Field trips
- Written test etc.
- Oral test.

The task assigned to the learner may be assessed on the basis of some indicators. Teacher may select one or more indicators depending upon the task assigned. On the basis of these indicators, teacher may assess the performance of learners while they are performing the task.

**Activity for assessment**

Learning by doing is an essential pedagogic strategy particularly in science. As far as possible, learners should perform the activities in groups. Working in groups is useful for assessing social values, cooperation. While assessing the activity - 1 some indicators of learning are given in column II. Activity specific indicators (What can be assessed?) are given in column III and assessment of learners (check list) are listed in column IV of the Assessment Table.

**Aim:** To study saponification reaction for preparation of soap.

### Assessment Table

<table>
<thead>
<tr>
<th>S. No.</th>
<th>Indicators of learning</th>
<th>Activity specific indicators (What can be assessed)</th>
<th>Assessment of learner (check list)</th>
</tr>
</thead>
</table>
| 1.     | Experimenting/Collecting data | Collects following apparatus/material  
- Caster oil(25mL, a sample of vegetable oil)  
- Sodium hydroxide  
- Common salt(10g)  
- Distilled water  
- Red and blue litmus paper strips  
- Two beakers(250mL)  
- Test tubes  
- Glass rod  
- Measuring cylinder(50mL): Knife | Whether required material/apparatus has been identified correctly. |
<p>|       | Cleans and dries glass apparatus before activity | Yes/No |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Presenting data</td>
<td>Puts required quantities of castor oil, sodium hydroxide, common salt and water</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Able to make 20% solution of sodium hydroxide.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Dips the blue and red litmus paper strips to check pH during the reaction mixture</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Tries to touch the beaker from outside. Uses the glass rod to stir the mixture on adding common salt till the soap begins to set.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Waits patiently for the soap to become solid</td>
</tr>
<tr>
<td>2.</td>
<td>Presenting data</td>
<td>Writes observations</td>
</tr>
<tr>
<td>3.</td>
<td>Analyzing data and drawing conclusions</td>
<td>Concludes that on cooling the mixture becomes solid</td>
</tr>
<tr>
<td></td>
<td></td>
<td>On putting a drop of reaction mixture of sodium hydroxide and castor oil on a piece of red litmus paper it turns blue whereas blue litmus paper remain blue only.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Heat is evolved on adding sodium hydroxide solution to castor oil.</td>
</tr>
</tbody>
</table>
| 4. | Providing explanations | Answers questions related to the procedure | • Why do we put the drop of reaction mixture on the litmus paper strips?  
• What does the evolution of heat on adding sodium hydroxide indicate?  
• Why common salt is added? |
| 5. | Asking question | Shows interest in getting related knowledge | • Can we use Na₂CO₃ instead of NaOH?  
• What is the chemical reaction involved in the manufacture of soap?  
• Can we separate glycerine from the reaction mixture? |
| 6. | Applications related to daily life | Students may relate to life experience such as cleansing action of soap. | Why are soaps used for cleansing purpose? |
| 7. | Values/Attitudes/Concerns | Washes and dries the apparatus after the activity. Uses chemicals judiciously | Yes/No |
Similarly, other tasks mentioned above can be assessed by selecting indicators. For field trip teacher can take students to visit the soap factory.

**Misconceptions that need to be addressed**

- It is essential that organic compounds should have hydrogen along with carbon.

- Another misconception is related to the formation of micelle. They think that micelle formation can take place in hydrocarbons also. This can be explained as follows:

  Soap molecules have two ends. The ionic–end of soap (which is hydrophilic) interacts with water molecules, whereas hydrocarbon chain (which is hydrophobic in nature), interacts with grease on the cloth. The grease on the cloth is pulled out with the soap when cloth is washed with plenty of water. If we try to dissolve soap in hydrocarbon and in case it dissolves and forms micelle, the hydrophobic end of the soap will form outside part of the micelle and hydrophilic part i.e. charged portion of the soap molecule will be oriented in the inside portion of the micelle because hydrocarbon part will dissolve in hydrocarbon as discussed above. Since in this situation number of same charges inside the micelle will be very large, and repulsion between these charges will make the micelle unstable or in other words micelle will not be formed.

**Assessment**

Teacher may assess the student on the basis of asking some questions. Two such questions are given here.

1. Do you think that the following compounds belong to the same homologues series: Justify your answer
   
   (a) \( \text{C}_2\text{H}_4 \)  
   (b) \( \text{C}_2\text{H}_2 \)

2. Which of the following belongs to the same homologues series:
   
   (a) \( \text{C}_3\text{H}_8\text{O} \)  
   (b) \( \text{C}_2\text{H}_5\text{COOH} \)
   
   (c) \( \text{CH}_2\text{O}_2 \)  
   (d) \( \text{C}_3\text{H}_11\text{OH} \)
Photosynthesis

INTRODUCTION
All living organisms, plants and animals, need food for getting energy. Plants synthesize their own food in the presence of chlorophyll from carbon dioxide and water, and for this process they use solar energy. On the other hand animals get their food from plants directly or indirectly.

KEY CONCEPTS
- Autotrophs synthesize their own food by the process of photosynthesis.
- Sunlight, water, carbon dioxide and chlorophyll are essential in the process of photosynthesis.

PRIOR KNOWLEDGE REQUIRED
- Food is synthesized mainly in the leaves of the green plants.
- Only green plants are able to prepare their own food by the process of photosynthesis.

TRANSACTION STRATEGY
Concept 1: Autotrophs synthesize their own food by the process of photosynthesis.
To introduce the concept of photosynthesis you can help the students to link their previous knowledge regarding autotrophic nutrition. They would already be aware of what the plants require to carry out the process of photosynthesis. An understanding can be built by providing a little more information on how these components are utilized by the plants during the process of photosynthesis. It is important to focus here that though photosynthesis takes place in green plants, it also takes place in some other organisms such as Euglena. You may also lead to the concept of storing of the prepared food by them in the form of starch. The significance of photosynthesis as a source of food for animals may be discussed by asking questions as given below.

1. How is photosynthesis important to animals?
2. Can life exist without photosynthesis?

Concept 2: Sunlight, water, carbon dioxide and chlorophyll (a green plant pigment) are essential for the process of photosynthesis.
Students may be helped to understand the basic requirements for photosynthesis by providing the chemical equation for photosynthesis.
given below and then initiating the discussion through questions and summarising the responses.

\[
6\text{CO}_2 + 12\text{H}_2\text{O} \xrightarrow{\text{Sunlight}} \text{CH}_2\text{O}_6 + 6\text{O}_2 + 6\text{H}_2\text{O}
\]

To demonstrate that carbon dioxide, sunlight and chlorophyll are essential for photosynthesis, simple activities can be performed as given below.

Before conducting the activities, a discussion may be initiated by asking questions such as

- How can it be assured that photosynthesis has taken place in a plant?
- What raw materials are required for the formation of glucose in plants?
- Would photosynthesis take place if leaves of a plant were not green?
- How can we test that carbon dioxide, chlorophyll and sunlight are essential for photosynthesis?

The students may then be helped to perform activities to observe the effects of factors essential for photosynthesis. However, before performing the activities students should be familiarized with the three processes given below.

I. Destarching leaves

Keep a well watered potted plant in a dark place (or covered by black paper) for 3-4 days so that any starch present in its leaves gets converted into sugar. This process is called destarching.

II. Removing chlorophyll from the leaf

- To remove chlorophyll from the leaf, the leaf is first boiled in water for some time. It is then removed from water, cooled and then transferred to a boiling tube containing alcohol. This boiling tube along with the leaf is placed in a beaker containing hot water till all of the chlorophyll extracted in alcohol and the leaf becomes colourless.

  **Precaution:** Do not heat the boiling tube containing alcohol on direct flame. Also, do not dip the boiling tube in a beaker containing boiling water as the alcohol contained in the boiling tube will evaporate quickly and the leaf will not be in contact with the alcohol for sufficient time for the complete removal of chlorophyll in the alcohol. The alcohol and the leaf in the boiling tube should be kept in a beaker with hot water which serves as a water bath.

III. Test for the presence of starch:

For this, chlorophyll is removed from the leaf as explained above, and 2-3 drops of iodine solution are poured on to the leaf. After a few minutes, excess iodine is washed out from the leaf and its colour is observed. If blue colour appears, the leaf contains starch and if the blue colour does not appear, it means starch is absent.
**Activity 1**

**To demonstrate that sunlight is essential for photosynthesis.**

(Note: A demonstration of this activity may be given in the class.)

**Materials required**

- A well watered potted plant (Impatiens, Tradescantia, Pelargonium, French bean, Coleus, Tecoma, Salvia), black paper/aluminium foil strip.
- For test — Iodine solution, alcohol, water, petridish, dropper, beaker, burner, tripod stand, wire gauze.

**Procedure:**

1. Take a destarched plant.
2. Select one leaf at the top of the shoot, preferably one held out from the stem nearly horizontal. Wrap a part of the leaf with a strip of black paper/aluminium foil. Press strip of the paper sheet or the aluminium foil to avoid exposure to light.
3. Leave the plant under direct sunlight for about 4-6 hours to allow photosynthesis to occur.
4. Pluck the experimental leaf from the plant and remove chlorophyll from it and perform the iodine test for starch.

**Results of activity -1** may be discussed with students by asking the following questions and writing a summary of results on the blackboard.

- What colour does the exposed part and the covered part of the leaf show in the iodine test for starch?

(Note for the teacher: The leaf should show some shade of blue in the part exposed to light. The part covered with foil/paper, which has no exposure to light, will stain yellow with iodine solution.)

- What does the appearance of blue colour in the area exposed to light indicate?
- Why does the covered area not show the appearance of blue colour in the test for starch?
- What does the appearance of blue colour in starch test indicate?

(Note for the teacher: Appearance of blue colour indicates the presence of starch. It suggests that starch has been formed only in those parts of the leaf which were exposed to the light.)

- Why does the part of leaf exposed to light show the formation of starch and covered part does not show the formation of starch?
- How could this be explained with reference to photosynthesis and light?

(Note for the teacher: Some stages of carbohydrate production in photosynthesis need a supply of energy from light. If this energy is lacking, starch cannot be produced.)

- Explain what are the assumptions made in the destarching process?

(Note for the teacher: One can assume that after keeping the plant for 3-4 days in darkness, starch is removed from the leaves and cannot be formed unless kept in sunlight again.)
Alternate activity 1:
To demonstrate that the light is essential for photosynthesis.

Material required:
*Hydrilla plant*, water beaker, funnel, test tube etc.

Procedure:
1. Place *Hydrilla* plant in two separate beakers containing pond water/tap water and cover both of them by a funnel.
2. Now invert a test tube full of water over the stem of the funnel in both the sets.
3. Place one set up in the sun light and another in dark (or covered with black paper).
4. Observe them after 30-40 minutes.

Precautions (for Alternative activity):
1. *Hydrilla* is an aquatic plant so it should be collected in the same water in which it was growing to maintain the same ionic environment needed for its normal growth and bring it to the lab.
2. Healthy branches of plant should be selected and the stem is cut obliquely to increase the surface area. This will help in releasing larger size of air bubbles from the stem.
3. Place the cut end of the stem toward the neck of the funnel.

**Fig. 2**: Experiment to show that light is essential for photosynthesis

**Note For The Teacher**
Air bubbles will be released from the *Hydrilla* plant in the set-up kept in the light.

Discussion on the concept can proceed through questions as follows:
1. What do you observe in the set-up kept in sunlight?
2. What has happened in the set-up placed in dark?
Activity 2

To demonstrate Chlorophyll is essential for photosynthesis.
(Note for the teacher: You can demonstrate this activity in the class.)

Materials required:
- A well-watered potted plant having variegated leaves e.g. Crotons, certain money plants.
- Iodine solution, alcohol, water, petridish, dropper, beaker, burner, tripod stand, gauze.

Procedure
1. De-starch the plant as in the previous activity and perform the iodine test as explained above.
2. Now keep the plant in sunlight for about 4-6 hours.
3. Detach a leaf from near the top of the plant and make a drawing of the detached leaf in your notebook and mark the outline of green and non-green areas of the leaf in the drawing.
4. Test the detached leaf for the presence of starch after removing the chlorophyll as explained above.
5. Alongside your first drawing of the leaf, make a similar drawing of the leaf after testing the leaf with iodine (starch test). Mark the outline of the areas stained blue–black and brown in the iodine test. The blue colour is due to starch and the brown colour is due to staining of the tissue of the leaf with iodine.

Results of Activity - 2 may be discussed with students by asking the following questions and summarising the results.

1. Look at the drawing of the leaf drawn by you before and after the iodine test. Do you find any relationship between the distribution of green colour in the leaf and the distribution of starch revealed by iodine?

Note for the teacher: 1. There should be an exact correspondence between the previous distribution of green colour indicating presence of chlorophyll and the distribution of starch in the leaf after iodine test.

2. Which areas of the leaf do not show formation of starch?

3. How the distribution of starch may be explained in terms of photosynthesis?

Note for the teacher: Starch has been produced only in the green areas presumably because chlorophyll is necessary for photosynthesis.

Note For The Teacher
- It is necessary to draw the leaf on a paper (preferably butter paper) before testing it for starch because when the leaf is fully decolourized, it will be difficult to remember exactly where the non-green parts of variegated leaf were present in order to compare the pattern of starch distribution with the pattern of chlorophyll distribution.
- There is no need to perform a separate control experiment because the control in this case is the presence of chlorophyll in the leaf so that a variegated leaf acts as both experiment as well as the control.
Activity 3
To demonstrate that the gaseous exchange takes place through stomata during photosynthesis.
Stomata are the minute pores on the surface of leaves through which atmospheric carbon dioxide is taken in by the plants during photosynthesis. Also, the oxygen produced in this process is released through these pores.

Materials required
A well watered potted dicot plant (e.g. Bryophyllum, Tecoma), Petroleum Jelly/grease, iodine solution, petri-dish etc.

Procedure
1. Destarch the plant as explained in previous activities.
2. Select two leaves from destarched plant and put a thin layer of grease/petroleum jelly on the under surface of one leaf and on both surfaces of other leaf.
3. Leave the plant under direct sunlight for about 4-6 hours to allow photosynthesis to occur.
4. Now pluck the experimental leaves and any other leaf of the plant (as control) and remove chlorophyll from these and perform starch-test explained earlier.

1. Which of the three leaves show the maximum starch formation?
2. Why starch was not seen in the leaf which was smeared with petroleum jelly given on both the sides?
3. Why in one leaf only the lower surface of the leaf was smeared with the petroleum jelly?

Note for the teacher: In leaves of dicot plants stomata are present mainly on the lower surface only, whereas the leaves of monocot plants stomata are present on both surfaces.

Activity 4
To demonstrate that carbon dioxide is essential for photosynthesis.

Materials required
A well watered potted plant, wide mouth bottle, a split cork, KOH solution (caustic potash), alcohol, iodine solution, petroleum jelly, beakers, a petridish, forceps, a burner, tripod stand, wire gauze and clamp.

Procedure
1. Destarch the plant and test 2-3 leaves for the presence of starch in them.
2. Fill one fifth of a flask with KOH solution.
3. Take a cork which fits onto the mouth of the flask and split it into two.
4. Insert one of the intact leaf of the destarched plant in a flask containing KOH solution, through the split cork fixed at its mouth, so that half of the leaf remains in the jar and half of it remains outside the jar as shown in Fig. 4. Ensure that the leaf does not touch the KOH solution. The role of KOH is to absorb CO₂ present in the flask.
5. Make the flask air tight by applying a thin smear of petroleum jelly at the mouth of the flask.
6. Keep the set up in bright sunlight for about 5-6 hours.
7. Detach the experimental leaf and perform starch test on it after removing chlorophyll.

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Results of the Activity - 4 may be discussed with students by asking the following questions.

1. Do the parts of the leaf inside the flask and outside the flask show the same colour in the iodine test? What difference do you observe?

**Note for the teacher:** The part of leaf inside the flask shows yellow colour after the starch test with iodine. This indicates the absence of starch. The part outside the flask shows blue-black colour in the test for starch, indicating the presence of starch in it.

2. In iodine test, why does the blue-black colour not appear in the part which was inside the flask?

**Note for the teacher:** Formation of starch in a leaf is the evidence of photosynthesis. Blue-black colour does not appear in the part enclosed in the flask because KOH absorbs all the carbon dioxide present in the flask.

3. Make a general statement about the importance of carbon dioxide in photosynthesis.

**Note for the teacher:** These results suggest that photosynthesis takes place in the presence of carbon dioxide.

**Alternative activity 4a**

To demonstrate that the Carbon dioxide is essential for photosynthesis

**Material required:**

Beaker, *Hydrilla* plant, funnel, test tube, KHCO\(_3\)/NaHCO\(_3\)

**Procedure:**

1. Arrange two set-ups for this activity same as in alternate activity (I).
2. In addition to this, two-three pinches of KHCO\(_3\)/NaHCO\(_3\) must be added to the water of one of the set-ups.
3. Both the set-ups with and without KHCO\(_3\)/NaHCO\(_3\) kept in sunlight.
4. Observe both the set-ups for the process of photosynthesis.

**Proceed with the discussion through questions such as given below:**

1. In which set-up you observe more bubbles are released?
2. What conclusion you draw with rapidly releasing bubbles in one set-up?

**Note for the teacher:** Due to availability of more carbon dioxide as a result of addition of KHCO\(_3\)/NaHCO\(_3\), rate of photosynthesis will be increased and more bubbles will be released rapidly.

- Avoid using leaves with thick waxy cuticle for all the above activities.
- Alternatively, the following activity can be performed to show that carbon dioxide is important for photosynthesis.
Alternative activity 4b

- Take two healthy plants which are nearly the same size.
- Keep them in a dark room for three days.
- Now place each plant on separate glass sheet.
- Place a watch glass containing potassium hydroxide by the side of one of these plants to absorb carbon dioxide.
- Cover both the plants separately using bell jars as shown in Fig. 5.
- Use petroleum jelly to seal the space between the bottom of the jars and the glass plates so that the setups become air tight.
- Keep the plants in sunlight for two hours.
- Pluck a leaf from each plant and test for the presence of starch as explained in the above activity.

Teachers should know the details of the following events:

1. Absorption of light energy by chlorophyll.
2. Conversion of light energy into chemical energy and splitting of water molecules into hydrogen and oxygen.
3. Fixation of carbon dioxide to produce carbohydrates.

   - The above steps do not necessarily take place one after the other immediately. For example, desert plants prepare an intermediate using carbon dioxide at night which is converted to carbohydrate during the day time using solar energy absorbed by chlorophyll.
   - The light dependant and light independent reactions occur simultaneously. The light independent reactions are driven by ATP made by light dependent reactions. Both systems shut down in the dark, but the light independent reactions can last a little longer if there is ATP remaining in the chloroplasts.
   - Photosynthesis is the respiration of plants.
   - Plants photosynthesise and animals respire.
   - Photosynthesis is a gaseous exchange process during which CO$_2$ is being taken inside and O$_2$ is released outside.
   - When plants carry out photosynthesis, they do not respire.
   - Respiration in plants does not take place in day time while the process of photosynthesis undergoes.
   - Respiration in plants takes place only in night.

Enrichment for Teachers

Fig. 5: Experimental set up:
(a) with potassium hydroxide
(b) without potassium hydroxide

Misconception that need to be handled

CO$_2$ evolved in respiration is used by the plants for photosynthesis during the day time.
• The most common misconception about photosynthesis is that plants get energy they need, from the sun only, they make sugars and other molecules for other organisms. The fact is that energy obtained from the sun is used to power photosystem-II of photosynthesis and, the ATP that is being produced does not leave chloroplast. To get energy for the requirements of its cell, plants must break down the sugars produced using glycolysis and cellular respiration. Plants also use the compounds they produce to build their own cell parts.

• Students often believe that photosynthesis is a plant’s way of cellular respiration. But all eukaryotes including plants carry out cellular respiration. Overall, photosynthesis is an endergonic process which stores energy in molecules, while respiration is an exergonic process which releases energy for the cell to use.

**Assessment**

1. Why is the potted plant kept in a dark place for 3-4 days at the beginning of experiments done to verify factors essential for photosynthesis?

2. Why is it important to test a few leaves for the absence of starch after destarching a potted plant while conducting experiment for factors essential for photosynthesis?

3. Why is the potted plant kept in sunlight for 6-8 hours after fixing the black paper strip on leaf?

4. Why is the leaf placed inside boiling tube, kept in boiling water for a few minutes before dipping in alcohol?

5. What is the role of alcohol in the question 4?

6. What is the role of KOH pellets in the experiment in which it is verified that carbon dioxide is essential for photosynthesis?

7. In activity 2 why does the variegated part of the leaf does not show the blue colour in iodine test?

8. Suppose, two leaves are given to you. One of the leaves is from the plant kept in dark for 3-4 days and the other one is from the plant kept in bright light. How will you distinguish between the two leaves?
We know that organisms, both plants and animals produce their offspring so as to maintain their race. You must have observed that in a field of sugarcane, which reproduce asexually, most of the plants are quite similar with each other and they show very little variation (difference). However if you take the example of a sexually reproducing organisms, say dogs, variations are quite visible among the puppies. It is exactly that you would learn how these similarities and variations appear in nature.

Heredity and variation go side by side and are the basis of evolution. The branch of biology which deals with facts and laws governing heredity and inherited similarities and variations is known as genetics. Genetics is the science which tries to explain why living thing resemble their parents and yet differ form them.

During studies, students need to master the skills of learning and communicating and develop self reliance and lifelong learning techniques. Most of the concepts and ideas are abstract, so these are difficult to transact. If not transacted cautiously and appropriately, the topic becomes uninteresting. Some strategies are given below to make the teaching-learning of this topic enjoyable.

There are many terms in this chapter which need to be understood clearly with examples before explaining any concept. Some of these terms are given below:

- **Gametes**: Male or female sex cells i.e. sperm and the ovum.
- **Chromosome**: Thread-like structures present in the nucleus, formed of chromatin material.
- **Variation**: Different characteristics produced in an individual through sexual reproduction.
- **Gene**: A part of chromosome which forms a unit of inheritance. Genes are transferred from parents to offsprings through chromosomes in the nuclei of the parent’s gametes (sperms and eggs).
- **Trait**: Genetically determined character of an organism.
- **Alleles**: Alleles are the two alternate forms of a gene.
- **Dominant gene**: Expresses itself in a heterozygous organism.
- **Recessive gene**: The gene which can not express itself in the presence of a dominant gene.
Homozygous – Both alleles of a gene are identical.

Heterozygous – Both alleles of a gene are dissimilar, i.e. one dominant and one recessive allele for a particular characteristic.

Genotype – Genetic constitution of an organism.

Phenotype – Visible expression of a gene.

Here under this topic, concepts of monohybrid and dihybrid crosses have been explained with the help of simple activities which will make the topic interesting. A group activity has been provided to explain the concept of natural selection. The concept of speciation due to geographical isolation has been explained through group activity. Some concepts such as homologous and analogous organs have also been explained using figures.

1. Variations exist in the living world.
2. Every individual organism looks more similar to its parents than non-related individuals.
3. Traits (genetically determined characters of organisms such as hair colour, flower colour, ear lobe, widow’s peak, height, etc.) are inherited but variations still occur in offsprings.
4. Certain traits can remain hidden in some generations and are expressed in future generations.
5. Mendel’s Rules of inheritance, i.e.
   (a) Two copies of genes for each trait are inherited in each sexually reproducing organism.
   (b) Both the copies of genes for each trait separate from each other during the formation of gametes.
   (c) Genes for different traits assort independently of one another during the formation of gametes.
   (d) Only dominant trait is expressed in hybrid progeny.
6. Each trait is controlled by two genes. One of these genes comes from mother and the other from father.
7. Inheritance of a single trait through monohybrid cross.
8. Inheritance of two traits through dihybrid cross.
9. DNA is a genetic material.
10. Sex determination in animals including humans.
11. Natural selection.
12. Genetic drift.
15. Analogous organs.

- Meaning of self pollination.
- Meaning of cross pollination.
- In sexual reproduction gametes are formed.
Each gamete has half the number of chromosomes in comparison to that of the parental chromosome.

Gametes combine together to form zygote.

Fusion of gametes is called fertilization.

Zygote develops and becomes an individual.

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**Activity 1**

**Why do I look like my parents or grandparents?**

**Purpose of the activity:** To help students understand the following concepts:

- Variations exist in the living world.
- Every individual organism looks more similar to his/her parents than to non-related individuals.
- Traits are inherited but variations still occur in the offsprings.
- Certain traits can remain hidden in some generations and are expressed in other generations.

**Initiating the activity:**

Group your class into four or five teams. Pick up any one of the following traits which is genetically determined and ask the students to note how many students of their team possess that particular trait.

(i) Attached/free ear lobe
(ii) Presence/absence of widow’s peak
(iii) Presence/absence of cleft in the chin
(iv) Ability to roll the tongue

**Proceeding with the activity:** Let students make their own observations. You may guide the students if they are unable to identify the characters.

**Discussion:** Carry out the discussion by asking the questions in the following manner—

(Following discussion is based on ear lobe feature)

- Do all the group members have attached ear lobe/free ear lobe?
- How many of them have attached ear lobe/free ear lobe?
- Do the family members of the individuals who have attached/free ear lobe also have the same feature?
- Which family members possess that feature?
- Discuss the results obtained and help the students understand that there are variations in populations.

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**Project:** Assign one trait to each team and ask the teams to collect the data on the particular trait assigned to the team from 10 families (preferably covering three generations) in their locality who are not blood related and ten families who are their relatives. If each group consist of five students, then each student may collect data from two families who are not related to them and from two families who are related to them.

**Guidelines to be provided by the teacher to the students which will help in data collection:**

Ask the students to note the following points during data collection:

- Similarities and differences found in the assigned feature in mother, father, and children.
- Resemblance of the feature in the family members (assigned to the group)
• Grouping of family members in terms of resemblance. For example, similarity amongst females or similarity amongst males.
• Compiling the data in tabular form.

Carrying out discussion:
Ask the groups to present their data in the class. Now carry out the discussion through the questions as follows:
• Do the children resemble their parent(s) in the particular trait (character) assigned to the group?
• Is the character found in all the members of the family?
• Is the character found in some/all the members of the society?
• Is the same pattern of resemblance in character between parent(s) and children found in every family?
• Ask the teams to find out if the character assigned to them is present in a child, is it present in father and/or mother or one of them or none of them.
• At this point help the students to reach the conclusion that children resemble their parents but variations may occur.
• Help the children discuss and arrive at the conclusion that characters are transferred from parents to children.
• Explain that if a character is present in one or both the parents, it may or may not be seen in the child. The character may remain hidden.
• Help the children arrive at the logical conclusion that if a character is present in children and the grandparents, and is not seen in the parents of the children then that character is hidden in the parents.

Conclusion: You must have seen that variations are invariably observed in a population. Thus we can conclude that the closer the relationship between two individuals the lesser the variation.

Note for the Teacher:
This activity should be performed to give the students a preliminary idea that characters are passed on to the next generation. How the characters are inherited should not be discussed at this point of time.

Assessment
1. Which of the following situation(s) do you expect to observe?
   Your classmate has free ear lobes, then.
   (a) both the parents may have free ear lobes.
   (b) at least one of the parent has free ear lobes.
   (c) none of the parents may have free ear lobes
   (d) some of his brothers and/or sisters may have free ear lobes.
   (e) All the above situations.
2. What is your opinion about the statement “all the characters of parents are seen in all the children”?
3. If a character is seen in a child, and is not seen in his parent, can the grand parents of the child have that character? Why?
Mendel's laws of inheritance

Purpose of the activity:
1. To explain Mendel's laws of inheritance i.e.
   e) Two copies of each trait are inherited in each sexually reproducing organism.
   f) Both the copies of traits separate from each other during the formation of gametes.
   g) Genes for different traits assort independently of one another in the formation of gametes.
   h) Only dominant trait is expressed in hybrid progeny.
2. Each trait is controlled by two alleles. One of these alleles comes from mother and the other from father.

Note for the Teachers: Traits are expressed in contrasting forms. For example, ear lobe can be either free or attached as observed in the previous activity. Inheritance of such traits in contrasting forms has been explained by Mendel through his experiments on pea plants where he found that some forms of a trait are dominant over the other. Children can be made to understand the concept of dominant and recessive character through the following activity. It should be ensured before commencing the activity that students know that half of the chromosomes are inherited from mother and half from father. But at this stage, do not discuss the concept of crossing over as it may confuse the students.

Preparation before teaching: Every sexually reproducing organism inherits two copies of the same traits— one copy from the mother and the other from the father. Each copy is called allele. You can use red and white bead to represent alleles. The bead should be of uniform size. Place all beads in a container and mix them thoroughly. Designate the red beads to represent the allele for the dominant trait i.e., red colour of the flower and the white beads to represent the alleles for the recessive trait i.e., white colour of the flower. This means that combination of two white beads would give rise to white flower colour but the presence of one or two red beads in a combination would give rise to red flower colour. This means that red flower colour is dominant over the white flower colour. Any trait which is expressed (produced/visible) is called the phenotype. The red or the white flower colour is the phenotype for the flower colour. Other examples are tall and short plants, round and wrinkled seed pods, etc. The genotype consists of a set of alleles that determines the expression of a particular characteristic or trait. The genotypes for the flower colour may be different even when the phenotypes are same. For example, two red colour beads also give rise to red colour flower. Again one white colour bead and one red colour bead give rise to red colour flower. Make a key on the blackboard that correlates the three colour combinations and keep it covered. Do not use the term dominant or recessive on this key.

Proceeding with the activity:
1. Walk around the room and allow each student to select two beads at random from the container. Make certain that learners cannot see the colour of the beads while making their selection.
2. Ask the students to record the colour of the beads. Tell your students that if they have the same colour pair their combination is called homozygous and if it is of different colour combination it is called heterozygous. Each bead represents the genetic information in one of the parents. Ask your students if they have the homozygous or heterozygous combination.
3. Each student will be given two match boxes with beads in them to hold in hands. One box will be wrapped in red paper and the other will be wrapped in white paper. The red matchbox will represent the female parent while the white box will represent the male parent. The beads may represent a homozygous or heterozygous combination of a parent.
4. Now ask each student to mix the beads of two match boxes and then shake the beads in their hands. Now randomly select any two beads without looking and place it on the table to form a new combination.  

(Note for the Teacher: Each hand contributes one allele of each trait to each offspring. The students do not know which allele (whether dominant or recessive allele) they contribute. This suggests that both the copies of traits (alleles) separate from each other during the formation of gametes.)

5. The new combination represents the offspring. Ask them to record whether the new combination (offspring) is a homozygous or heterozygous pair. Thus the genotype of the offspring is also established.

Note: The new bead combination represents the genetic information that will determine the character in the offspring.

6. Uncover the colour key and ask the students the following questions –
(i) To which colour does your first bead combination correspond?
(ii) To which colour did the bead combination in each match box in your hand correspond?
(iii) To which colour does the new bead combination (offspring) correspond?

Note for the teacher: Do not introduce the terms dominant or recessive as yet.

7. As a part of a class discussion use the key once again and share results of the class to consider the following:
Did one bead colour (which corresponds to one piece (allele) of inherited genetic information) have a greater influence in determining the flower colour than the other bead colour?

8. The idea that one type of genetic information can be more powerful or influential than another type (dominant over the other) should strike the mind of the students as they compare the colour combinations from the class with the key.

Note for the teacher:

1. You may now introduce the word dominant and recessive at this stage. Tell the students about the convention that Dominant trait is represented by capital letter and Recessive trait is represented by small letter.

2. Avoid using the word monohybrid and dihybrid at this point.

3. During the activity, you can assess the students based on the discussions that have taken place. In addition assess them based on their participation and involvement.

**Assessment**

1. What is the difference between a dominant and a recessive trait?
2. Tall plant (TT) is dominant over short plant (tt). Which of the following progeny will be tall:
   (a) TT  (b) Tt  (c) tt  (d) tT
3. cross between a tall pea plant (TT) and short pea plant (tt) resulted in progeny that were all tall plants because of which of the following reasons:
   (a) Tallness is the dominant trait
   (b) Shortness is the dominant trait
   (c) Tallness is the recessive trait
   (d) Height of pea plant is not governed by gene ‘T’ or ‘t’
4. Give an illustration to show the appearance of a recessive trait in the F1 generation.
   Consider the following family tree on ‘cleft chin’ which is a recessive trait and is expressed in homozygous condition. Answer the questions following the tree.
Discuss the answer keeping in view atavism (recurrence of a trait typical of an ancestral form). But do not use the term to the students.

Inheritance of a single trait through monohybrid cross

Purpose of the activity: To explain the concept of inheritance of a single trait through monohybrid cross. This activity will also explain that both the copies of traits separate from each other during the formation of gametes.

Preparation before teaching: Take any trait of a plant, for example, seed colour with two contrasting colours – green and yellow. Take green colour as the dominant character/form and yellow colour as the recessive character/form.

Requirements: 16 Yellow and 16 Green coloured Seeds/beads having same size and texture, taken in bowls/any container.

Proceeding with the activity:
1. Put 16 Yellow beads and 16 Green beads in two separate bowls indicating the gametes of male and female parent, respectively. You can consider any colour as male or female gamete. (The beads will also represent the gametes)
2. To show the F1 generation makes pairs of beads by picking one bead each of Yellow and Green.
3. Continue to form 16 pairs. You have now created F1 generation which consists of 16 pairs of beads (each pair consists of one Yellow and one Green).
4. Record the phenotypes of the F1 generation that you have created.
5. Divide the 16 pairs into two sets. Each set now contains 8 pairs and each pair consists of one Yellow and one Green bead. Put the two sets separately. The two sets represent the male and female parents.
6. To show selfing (self pollination) of the F1 generation randomly, pick one bead each from each set without looking.
7. Continue to pick the beads randomly to form 16 pairs once again. These 16 pairs represent the F2 generation.
8. Now note down the phenotype based on the colour of the beads of each pair. Keep in mind that green colour is dominant over yellow (Two green beads = green colour seed; one green + one yellow bead = green colour seed; two yellow beads = yellow colour seed).
9. Repeat the process from step number 3 to 7 three or four times and each time note down the ratio of the green and yellow phenotypes of the pairs.
10. Calculate the average ratio of green and yellow seeds/beads based on the phenotypes.

Discuss the results and observations of a single observation and also of repeated observations. Elaborate how traits are inherited in monohybrid crosses. Explain how a trait that is not visible in the F1 generation, re-appears in the F2 generation to clarify the concept of law of segregation.
Note For The Teacher

Explain to the students why the activity was repeated. You can also try out the same activity by increasing or decreasing the number of beads used. For example, you can try out by using 32 beads of each colour or 64 beads of each colour. Find out if there is any difference in the ratio obtained.

Assessment

1. Which of the trait is expressed more often and why?
2. What is a monohybrid ratio?
3. Why did we repeat the experiment?
4. How many traits are taken into account in a monohybrid cross?
5. A minimum of how many alleles can be present for each trait?
6. Write in your own words what do you understand by law of segregation.

Activity 4

Inheritance of two traits through dihybrid cross

Purpose of the activity: To explain the concept of inheritance of two traits through a dihybrid cross.

Requirements: 16 Yellow, 16 Green, 16 Purple, and 16 White coloured beads having same size and texture, bowls/any type of containers.

Proceeding with the activity:

1. Take 16 beads each of Yellow, Red, Green and White colours. Yellow and Red beads represent the dominant seed colour and flower colour, respectively. Green and White beads represent the recessive seed colour and flower colour, respectively.
2. Keep the Yellow and Red beads separate to represent male parent. Keep the Green and White beads separate to represent the female parent.
3. Separate the beads in containers representing different traits for each parent. Label container A for dominant seed colour (Yellow beads); Label container B for dominant flower colour (Red beads); Label container ‘a’ for recessive seed colour (Green beads); and label container ‘b’ for recessive flower colour (White beads).
4. To produce gametes, pick one bead each from container A and B. Continue till 16 pairs of beads are formed. These represent the gametes produced by male. Similarly, pick one bead each from container ‘a’ and ‘b’. Continue till 16 pairs of beads are formed. These represent the gametes produced by female.
5. To produce the F1 generation, pick one pair of male gametes (one pair of beads) and one pair of female gametes (one pair of beads) to form clusters. There will be 16 clusters representing 16 progeny. (You will find that each cluster consist of all the four colours of bead).
6. Note down the phenotype of the F1 progenies.
7. Separate the clusters into 2 groups to represent male and female parent (This will indicate selfing of F1 generation).
8. For both male and female parent separate the beads representing each trait. i.e., In the group that represent male, keep separately the beads for the seed colour and flower colour. Yellow and Green beads for seed colour in container P; Red and White beads for flower colour in container Q. Similarly, in the group that represent female, keep separately beads for the seed colour and flower colour. Yellow and Green beads for seed colour in container R; Red and White beads for flower colour in container S. (This is done to ensure that both traits are represented in the offspring but this do not occur in nature).
9. To form male gametes pick one bead each from container P and Q. Similarly, to form female gametes pick one bead each from container R and S. Continue to form gametes till all the beads are utilized.
10. To form F2 generation pick one male gamete and one female gamete. You will get 16 progenies each with a four-bead cluster.
11. Record the phenotype which is represented by each of the 16 clusters of four beads.
12. Repeat the whole process six times.
13. Tabulate your observations and calculate the ratio obtained.

14. You will find that F2 generation will consist of four phenotypes in the ratio of 9:3:3:1. Here, 9 represents plants with Yellow seeds and Purple flowers, 3 represents Green seeds and Purple flower and the other 3 represents Yellow seeds and White flowers and 1 represents plant with Green seed and White flower. Discuss the results and observations and elaborate how traits are inherited in dihybrid cross where the inheritance of two traits is taken into consideration. Explain how the ratio of 9:3:3:1 is obtained using Punnet Square instead of using beads. Explain that genes for different traits assort independently of one another in the formation of gametes. That is, in the activity we have seen that the presence of one gene for a trait do not determine which gene for another trait will be contributing during the formation of gamete as we saw in Step no. 9 of the activity.

**Note For The Teacher**

Explain to the students why the activity was repeated. You can also try out the same activity by increasing or decreasing the number of beads used. For example, you can try out by using 32 beads of each colour or 64 beads of each colour. Explain how the ratio of 9:3:3:1 is obtained using Punnet Square instead of using beads.

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**ASSESSMENT**

1. Did any of the offsprings in the F2 generation vary from their parents?
2. Why do we call the activity we just performed as dihybrid cross?
3. Why did we pick the beads randomly to raise F2 generation?
4. If a round, green seeded pea plant (RRyy) is crossed with wrinkled, yellow seeded pea plant (rrYY), the seeds produced in F1 generation will consist of which of the following:
   (a) round and yellow  
   (b) round and green  
   (c) wrinkled and green  
   (d) wrinkled and yellow
5. Two pea plants, one with round green seeds (RRyy) and another with wrinkled yellow (rrYY) seeds produce F1 progeny that have round, yellow (RrYy) seeds. When F1 plants are selfed, the F2 progeny will have new combination of characters. Choose the new combination from the following:
   (i) Round, yellow  
   (ii) Round, green  
   (iii) Wrinkled, yellow  
   (iv) Wrinkled, green
   (a) (i) and (ii)  
   (b) (i) and (iv)  
   (c) (ii) and (iii)  
   (d) (i) and (iii)
6. Study the following cross and showing self pollination in F1, fill in the blank and answer the question that follows.

<table>
<thead>
<tr>
<th>Parents</th>
<th>RRYY x rryy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Round, yellow</td>
<td>wrinkled, green</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>F1</th>
<th>RrYy x ?</th>
</tr>
</thead>
<tbody>
<tr>
<td>Round, yellow</td>
<td>?</td>
</tr>
</tbody>
</table>
Discuss the importance of this mechanism of restoring the number of chromosomes.

**Activity 5**

**Sex Determination in Humans**

**Purpose of the activity:** To explain the concept of sex determination in humans.

**Proceeding with the activity:**

Explain how sex is determined in human beings with the following illustration. Emphasize that sex of a child is determined by the type of sex chromosomes he or she inherits from the father.

If reproductive cells (sperm and egg) have the same number of chromosomes as other body cells which consist of 46 chromosomes, then each time they combine, the progeny would have twice the number of chromosomes. But this should not happen. So, there must be a process that halves the number of chromosome in reproductive cells. The following illustration explains how this happens.

**Assessment**

1. How many chromosomes will be present in the zygote based on the above illustration?
2. What are genes basically made up of?
3. Differentiate between reproductive and non-reproductive (somatic) cells.
4. Do you agree with the statement “gametes are made up of genes only”? Justify.
5. Is X-chromosome present only in egg (female gamete)?
6. What are the gametes that combine to give rise to a female child?

**Note For The Teacher**
Discuss in the class the possible ills of female foeticide in the society. Also sensitize the students to remove the misconception that ‘only the mother is responsible for determining the sex of the child.’

### Activity 6

**Natural Selection**

**Purpose of the activity:** To explain the concept of natural selection.

Perform the following activity to make students understand how natural selection leads to evolution of species.

**Materials required:** Hard papers of six different colours.

Proceeding with the activity:

1. Cut the papers into small pieces of a fixed shape (squares, circles, hexagon etc.) to represent different species of prey population.
2. Keep the pieces of different colours in different containers.
3. Divide the class into team of four students. Out of the four, one will act as the game observer and three will act as predators.
4. Take a large sheet of paper of any of the above colours and spread it on a table.
5. Choose one team of predators. Tell the predators to turn their back towards the table. Let the observer pick equal number of pieces of each colour (not less than 10) and spread them randomly on the sheet of paper ensuring that the pieces do not overlap each other. This will form the first starting population of prey.
6. Now the observer will ask the predators to turn and start hunting on the prey for 20 seconds. The observer must signal the **start** and **stop** for hunting.
7. Each of the predators will count their hunt and group different colours separately.
8. The observer will keep a record of the surviving population of each prey species.
9. The observer will add three prey of the same colour for every individual of each prey remaining on the paper sheet. This process of addition indicates reproduction in the surviving population before the next hunting round. This will form the second starting population of prey.
10. Repeat the process from point 6 to 9 two times.
11. Now tell the observer to count the survival of population after third round of predation based on the number and colour of prey population remaining on the sheet of paper. The observer will add three prey of the same colour for every individual of each prey remaining. This will form the fourth starting population of prey.
12. Present the four starting populations over generations in the form of bar graphs.

### Assessment

On the basis of the preceding activity discuss the following points in the class:

1. Which, if any, colours of paper squares had a better survival rate than other squares in the second, third and fourth generation starting populations?
Answer will depend on the colour of the paper sheet the students used. Note that the starting populations for the second and third generations should include more pieces that are similar in colour to the sheet of paper spread below them, and fewer pieces of other colours that stand out. The change between the first and the third generations should be more than the change between the first and second generations.

2. What might be the reason that predators did not select these colours as often as they did other colours?

**Answer:** Some colours were better camouflaged than others were; they blended into the environment.

3. What effect did capturing pieces of a particular colour have on the numbers of pieces of that colour in the following generations?

**Answer:** When an individual is removed from a population and dies, in this case, through predation, the reproduction rate of that population decreases. The students should realize that heavy predation leads to a decrease in the size of the population.

Also ask the students what physical or behavioral characteristics besides camouflage might be the basis of evolution by natural selection. This will help students generalize from the example of camouflage to other factors that contribute to reproductive success for example, better night vision, ability to move quickly, ability to survive with little water, etc.

**Note For The Teacher**

Besides asking the above questions you may also assess the students based on the following: Participation, team spirit, representation, data compilation and analysis of data.

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**Activity 7**

**Genetic Drift**

**Purpose of the activity:** To explain the concept of genetic drift.

**Requirements:** Paper/plastic cups, beads with yellow and green colours or any two colours to represent alleles.

**Proceeding with the activity:**

1. Take five cups and put yellow colour beads in each cup. Place the cups on a table.
2. Take another five cups and put green colour beads in each cup. Place the cups on the same table as the previous one.
3. Take ten empty cups and place them on a separate table.
4. Randomly pick the bead from one of the ten cups with beads and place it in any one of the empty cups. Replace the empty cup with the same colour bead again.
5. Continue till all the empty cups contain bead in it.
6. Note down how many cups contain yellow colour beads and how many contain green colour beads.
7. Remove the beads from the first ten cups.
8. Take the ten empty cups and repeat the activity as in Sl. No. 4.
9. Continue till all the empty cups contain bead in it.
10. Note down how many cups contain green colour beads and how many contain yellow colour beads.
11. This will be the generation No. 1 and now arrange ten empty caps on the other table.
12. Randomly pick the beads from generation No 1 and transfer it in any one of the empty cups. Replace the empty cut with the same colour bead again.
13. Continue the activity till all the cups contain the same colour beads.
Ask the students to repeat the same activity by increasing the population (i.e., starting the activity by increasing the number of cups and beads to 10 each) and find out if they could find any difference in their observations.

1. What do you think will happen to gene frequency if the population is large?
2. In the above activity, random sampling was done. Why is that important?
3. Explain the statement “Fewer the copies of an allele, larger is the effect of genetic drift”.

Speciation

Purpose of the activity:
1. To explain the concept of speciation which produces two or more separate species.
2. To understand the difference between inherited and acquired characters.
3. Speciation is a lineage-splitting event that produces two or more separate species.

Proceeding with the activity:
Here is one scenario that exemplifies how speciation can happen. The concept of speciation can be made simplified and clear in the class using the following imaginary scenario/analogy. Story telling approach can be used for this activity.

The scene: A population of houseflies feeding on dead cattle not very far from the sea. The houseflies are found laying eggs in the decomposing cattle. Some of the eggs have reached the larval stage. These larvae of the houseflies are called maggots.

Disaster strikes: A cyclone washes away the cattle which carried along with it the maggots that were feeding on it. The cattle eventually lands on an island far from the mainland. The maggots feeding on the cattle mature and emerge from the decomposed flesh of the cattle. The houseflies that emerge from the maggots are now too far apart for gene flow to unite with the housefly population in the mainland. At this point, speciation has not occurred - houseflies that could get back to the mainland by any means could still mate and produce healthy offsprings with the houseflies in the mainland.

The populations diverge: Ecological conditions in the island are slightly different from the mainland conditions. Therefore, the island population of houseflies evolves under different conditions. They go through different experiences and pressures as in selecting their mates, various ecological factors and other random events than the mainland population does. As a result, morphological features, food preferences, and mating behaviour change over the course of many generations of natural selection in the island population of houseflies.

The reunion: Another cyclone occurs, which reintroduces the island houseflies to the mainland. These island flies will not readily mate with
the mainland houseflies since they have evolved different mating behaviours. Even the island houseflies that are able to mate with the mainland houseflies are not able to produce viable eggs (eggs capable of surviving) because of other genetic differences that have occurred between the two populations. The lineage has split because now the genes cannot flow between the two populations. We can now say that speciation has occurred in the population of houseflies.

The above described situation is a simplified model of speciation by geographic isolation. It must be remembered that the exact sequence need not happen in the real-life cases.

1. What is the initial trigger for the formation of a new species?
2. Individuals of a population are introduced in two very different ecological conditions. Will they be able to produce viable individuals after many generations?

### Assessment

#### Activity

**Homologous organs**

*Purpose of the activity:* To make the students to understand the concept — Fundamental characteristics of organisms reflect their evolutionary relationships based on homologous organs.

Homologous organs are those which have a common ancestry or common origin and are built on the same fundamental pattern. However, these organs may have different function and have different structure (due to adaptation to perform different functions).

Based on the following, discuss the concept of homologous organs indicating common ancestry and significance in evolution.

**Proceeding with the activity:**

Ask the students to observe the photographs of the fore-limbs of different animals given in the chart below and ask them to list one similarity and dissimilarity in the structure and function of fore-limbs that they observed.

#### Activity 1

**Analogous organs**

*Purpose of the activity:* To make the students understand the concept — Fundamental characteristics of organisms reflect their evolutionary relationships based on analogous organs.

The analogous organs have almost similar structure and perform the same function, but they are not built on the same fundamental pattern and they have different origin.

**Proceeding with the activity:**

Show pictures of the wings of a butterfly, bird, and bat. Ask the students to find out if they could find any similarity or difference in the basic structure and in the function in the three types of wings.

Depending upon the discussion, lead them to understand the concept of analogous organs and their significance in the evolution.
Students have difficulty relating an individual’s adaptation to environment with changes in species phenotypes over long period of time due to selection or individuals can adapt to a changing environment. These adaptations are heritable.

**Explanation:** Individual adaptation to environment is an example of acclimatization which is adaptation to immediate environment which is not heritable. But when such changes occur repeatedly over many generations, then it could lead to selection of that particular acquired phenotype which will then be transmitted to subsequent generations.

### Assessment

1. Find out if the students have understood the concept of homologous and analogous organs by asking the following questions:
   a. Observe the two aquatic animals given below. What similarities do you observe in the body shape and structures?
   b. Whether the fin of the shark and the flipper of dolphin are homologous organs or analogous organs? Give reasons.

   ![Shark](image1.png) ![Dolphin](image2.png)

   c. What do you think about the patagium of bat and forelimbs of frogs? Do they indicate analogies or homologies? Explain.

2. What do you understand by convergent and divergent evolution? Explain by giving suitable examples.

3. Briefly explain the dissimilarities in appearance of real sisters and brothers?

4. The gametes (sperms and ova) have only half the number of chromosomes. Name the type of cell division through which they are produced.

5. Differentiate between the following pair of terms:
   (i) Homozygous and Heterozygous
   (ii) Phenotype and Genotype
   (iii) Dominant and recessive genes

6. Explain the concept of genetic drift by taking a suitable example.
INTRODUCTION

We see a huge variety of living organisms around us. We come across many type of plants like rose, mango, peepul, mint, grass, etc. We also see different kinds of animals from tiny ant to large camels and elephants. You should know that there are about 1 million species of animals and about half a million species of plants, which have already been described. It is humanly impossible to make an attempt to study such a huge variety of organisms. So it becomes essential to arrange these organisms in some way under different categories. This will make our study about the organisms convenient and easy.

KEY CONCEPTS

- Importance of Classification of organisms.
- Basis of Classification – similarities and dissimilarities.
- Meaning of term characteristics.
- Characteristics of body design that are used to place plants and animals in different groups.
- Characteristics that decide more fundamental differences among organisms and help in making broad groups of organisms.
- Hierarchy of classification groups.
- Characteristics that decide hierarchy in classification.
- Five kingdom Classification.
- Binomial Nomenclature.

PRIOR KNOWLEDGE REQUIRED

- There is a need to group the living organisms.
- Differences between unicellular and multicellular organisms.
- Differences between prokaryotic and eukaryotic cells.
- Differences between plant cell and animal cell.
- Knowledge of autotrophs and Heterotrophs.

TRANSACTION STRATEGY

Activity 1

Arrange an educational trip to some nearby field/park/garden. Students may be allowed to visit different localities around these locations. Ask them to note down the local names of various plants and animals found in these locations in their note books.

After their visit, let them group the plants and animals in different categories on the basis of following points:
The discussion may proceed with the help of questions. Some examples are given below:

1. Why have you put the plants and animals under separate groups?
2. What was the basis on which you categorize various plants under different groups?
3. On what basis you have put animals under separate groups?

Discussion should lead to the following conclusions:

- Biological classification attempts to group living organisms into different categories on the basis of similarities and dissimilarities between them.
- Organisms with similar characteristics are placed in one group, while organisms with different characteristics are kept in separate groups.
- Aristotle classified animals on the basis of their habitat whether terrestrial, aquatic or aerial. But this classification was misleading.
- Later on, scientists discovered that organisms can be differentiated and grouped in a better way on the basis of their cell structure, mode and source of nutrition and body organisation.

Choosing Characteristics which Form Basis for Hierarchy in Classification

- Occurrence of cells singly or in groups
  
  There are organisms like *Amoeba, Euglena, Chlamydomonas* etc., whose body is formed of only single cell. They are ** unicellular organisms.** On the contrary, there are many organisms whose bodies are formed of numerous cells. They are called **multicellular organisms** such as earthworm, cow, human beings, mango tree, rose plant etc.

- Presence or absence of membrane bound nucleus.
  
  In primitive organism like bacteria, nucleus is not surrounded by a nuclear membrane. The genetic material in such organisms is simply scattered in the cytoplasm. These organisms are called **prokaryotic** (Pro = primitive, Karyon = nucleus) **organisms.** On the contrary, most of the organisms have membrane bound nucleus. They are called **Eukaryotic** (Eu = true, Karyon = nucleus) **organisms.**

- Mode of nutrition: Autotrophic or Heterotrophic
  
  Green plants have the capacity to synthesise their own food by using carbon dioxide and water through a process called photosynthesis, which needs sun light. Plants utilize solar energy...
for this process. Thus the green plants are autotrophs (Auto = self; Trophe = nourishment or food). On the other hand animals and non-green plants are unable to synthesise their own food, hence they are called heterotrophs (Hetero = different; Trophe = nourishment).

In all the examples cited above a hierarchy is developed. There are many such characteristics which help us in developing the hierarchy, which form the basis of classification.

- Classification facilitates us to study a wide variety of organisms.
- Classification projects a picture of all life forms at a glance.
- It also helps us to understand the evolutionary relationship between different groups of organisms.

Earlier scientists generally agreed that all organisms should be placed in just two kingdoms, the animal kingdom and the plant kingdom as classified by Linnaeus in the 18th century. The basic difference between animals and plants is that animals feed on organic substance obtained from plant and animal sources (heterotrophs), whereas plants synthesise their own food using inorganic substances CO₂ and water (autotrophs).

- However, this classification ignored the fact that all cellular organisms may be categorized into two natural groups: prokaryotes and eukaryotes. These two groups are fundamentally different. In prokaryotes, DNA lies scattered in the cytoplasm. A well defined nucleus containing DNA material and surrounded by nuclear membrane is not present in prokaryotes. Thus the cells lack well-defined nuclei. The cells of eukaryotes, however, contain nuclei duly covered by a nuclear membrane.

- Classifying all animals and plants in this way presented other difficulties. For example, fungi are heterotrophic and non-motile, therefore cannot be classified as animals or plants. Such problems were solved by Robert Whittaker, an ecologist at Cornell University. In 1969 R. Whittaker devised a more complete, five kingdom system which is still widely used. Whittaker based his classification scheme on the following three levels of organization:
  (i) The prokaryotic versus eukaryotic structure of cells, (ii) the unicellular versus multicellular organisation, and (iii) the three different modes of nutrition photosynthesis (plants), absorption from the substrate (fungi) and ingestion (animals). Further classification is done by naming the sub-groups at various levels as given in the following scheme:
  - Kingdom
  - Phylum (for animals)/ Division (for plants)
  - Class
  - Order
  - Family
  - Genus
  - Species
Thus, by separating organisms on the basis of a hierarchy of characteristics into smaller groups, we arrive at the basic unit of classification, which is a ‘species’. So which organisms can be said to belong to the same species?

Broadly, a species includes all organisms that are similar enough and interbreed and produce fertile offspring.

**Note For The Teacher**

Now, discuss with students the characteristics of five kingdoms proposed by Whittaker.

- Presently, we widely use following five kingdom classification:
  - Kingdom Monera (Prokaryotic bacteria and blue green algae)
  - Kingdom Protista (Unicellular eukaryotic organisms like protozoans and algae)
  - Kingdom Fungi (Yeast, Mushroom)
  - Kingdom Plantae (Green plants and multicellular algae)
  - Kingdom Animalia (Multicellular animals)

I. **Kingdom Monera**

- No defined nucleus or organelles (prokaryotic).
- No multi-cellular body design.
- Some have cell walls, some do not.
- Mode of nutrition is either autotrophic or heterotrophic.

Examples are Bacteria and Anabaena

II. **Kingdom Protista**

- Unicellular eukaryotic organisms
- Some of these organisms use appendages, such as hair-like cilia or whip-like flagella for moving around.
- Mode of nutrition is either autotrophic or heterotrophic.
- They are multicellular eukaryotes.
- Their cells have cell walls made up of cellulose.

Examples are Paramecium, Euglena and Amoeba
III. Kingdom Fungi

- Heterotrophic eukaryotic organisms which use decaying organic matter as food and are therefore called saprophytes.
- Many of them have capacity to become multicellular organisms at certain stages in their lives. They have cell-walls made up of a tough complex carbohydrate called chitin. Examples are Aspergillus, Penicillum and Agaricus.
Arrange an educational trip to a park/garden/field and let the students observe different plants. Students may be asked to collect some plants and broadly categorise them according to their characteristics and make a list of plants falling under each of the broad categories given in the Table 9.1. They may be asked to use their own terminology for classifying plants. They should classify these plants on the basis of their own observations which they may record in the following Table 9.1. Now, let them verify from the textbook or other learning sites, up to what extent they have been successful in classifying plants.

Table 9.1: Broad categories of plants

<table>
<thead>
<tr>
<th>S.No.</th>
<th>Thallophyta</th>
<th>Bryophyta</th>
<th>Pteridophyta</th>
<th>Gymnosperm</th>
<th>Angiosperm</th>
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Compare your observations with the given flow chart and check if there is any difference.
**Kingdom Plantae**

They synthesise their own food by the process of photosynthesis.

**Kingdom Plantae (Plants)**

- **Thallophyta**: Plants not differentiated into roots, stems and leaves, e.g., *Spirogyra*
- **Bryophyta**: Plants without true roots but with distinct stem and leaf-like structures, e.g., *Funaria, Marchantia*
- **Pteridophyta**: Plants differentiated in roots, stems and leaves, e.g., *Ferns*
- **Gymnospermae**: No true flowers, naked seeds, e.g., *Pines, Yews*
- **Angiospermae**: Flowering parts with true flowers, seeds enclosed within fruits

**Kingdom Animalia**

**Basis of Classification**

Animals are classified on the basis of certain (visible) features like body-organisation, symmetry, etc.

**Organisation:**

Even in certain multicellular animals, for examples in sponges, the cells are not organized as tissues and organs. The sponges are simply aggregate of cells. This is called cellular level of organization but in higher animals, the cells are organised as tissues (as in coelenterates which have a tissue grade of organization). In still higher animals (like frog) the tissues are organised into organs and further as organ-systems.

**Symmetry:**

Symmetry means dividing the body into equal and identical parts. *Amoeba* is an asymmetrical animal/star fish is radially symmetrical, while the other animals like cockroach, man etc. are bilaterally symmetrical.

**Body cavity or coelom:**

It is a cavity between the body wall and the alimentary canal (gut). It is absent in acelomates like Tapeworm, pseudocoelomate as in round worm. But it is present in Coelomates as in earthworm, frog, man, etc.

**Embryonic layers:**

There are three layers of cells namely, ectoderm, mesoderm and endoderm in the embryonic stage. From these layers that all the organs of the body of an animal are formed. Sponges and coelenterates do not have mesoderm and they are called as diploblastic. Other animals have three layers of cells and are called triploblastic.
**Notochord:**

The notochord is a stiff rod-like structure running along the body, close to the dorsal surface. It provides support to the animals. All chordates possess a notochord at some stage or the other during development. This notochord is absent in invertebrate animals hence they are also called non-chordates.
Why is there a need for systematic naming of living organisms?

Activity 3

Students may be asked to find out the names of following animals and plants in different languages.

1. Peacock 2. Cat 3. Lion 4. Ant

We find that different animals and plants have different names. For instance, a cat is called ‘billi’ in Hindi, ‘biral’ in Bengali, ‘Vedal’ in Sanskrit and ‘Punai’ in Tamil. Thus a need was felt to assign a particular organism with an internationally acceptable name. The scientific name of an organism should be unique so that it can be used to identify it anywhere in the world.

The system of scientific naming or nomenclature was introduced by Carolus Linnaeus. Under this system each organism has a scientific name consisting of two parts. First part is genus name and second part is species name. For example, the scientific name of tiger is *Panthera tigris*, where *Panthera* is genus name and *tigris* is the species name.

Misconceptions to be Handled

1. Snakes nod their hood when snake charmers play “been” though they do not have ears. Snakes simply perceive the movement of the snake charmer and “been” and thinks that the charmer is going to hit by the “been”, so that snakes try to save themselves.

2. *Sycon* and *Spongilla* (sponges) are non-living.
   
   Infact for a very long time, the sponges were regarded as non-living. It was thought that these sponges are simply the nests of various marine worms and larvae of crustaceans, but later on when water currents were seen entering into the bodies of sponges and coming out-of them, they were considered as animals.

3. *Hydra* and other coelanterates were regarded as plants.
   
   It was a misconception till scientists observed movements of their body parts, they were classified as animals.

4. Bats are birds.
   
   Bats are mammals as their females have mammary glands, feed their babies and give birth to fully developed young ones(viviparous).

Assessment

1. Why are blue green algae put under kingdom Monera alongwith bacteria?
2. Though *Euglena* has green colouring matter (chlorophyll), yet it is not regarded as plant. Why?
3. Why earthworms are regarded as farmer’s friends?
4. Why is Torpedo called electric ray?
5. Name the reptile which show-camouflage.
6. Though most of the Reptiles lay eggs, yet there is one group of reptiles whose females give birth to the young ones.
7. Name one oviparous mammal.
INTRODUCTION

Sound is a form of energy which Travels in the form of mechanical waves and produces sensation of hearing in our ears. In this chapter an effort has been made to help learners understand the nature of sound, mode of its propagation through a medium with the help of a set of activities as well as mental model. Sound waves are conceived to be propagating through air in the form of series of compressions and rarefactions. Many of us find it difficult to comprehend how compressions and rarefactions are formed and how they move in a medium. The longitudinal nature of sound waves and their graphical representations has also been discussed.

Understanding the terms like frequency, amplitude and speed in the context of sound waves and how do they determine the characteristics of sound such as loudness, pitch and quality (or timber) can be developed through a set of activities. Reflection of sound and related phenomena like echo and reverberations could also be demonstrated and linked with everyday experiences.

It is envisaged that this presentation would enrich understanding different aspects of sound and facilitate teaching-learning.

KEY CONCEPTS

- Sound is produced by a vibrating body.
- Sound is a form of energy which propagates through a material medium in the form of a wave.
- A sound wave is a periodic disturbance that moves through a medium when the particles of the medium set neighbouring particles into motion.
- Sound is characterized by its loudness, pitch and quality (or timber).
- Sound needs a material medium to propagate. Particles of the medium vibrate about their mean positions when sound propagates through it.
- Sound propagates as longitudinal wave in fluids (liquids and gaseous media).
- The speed of sound is different in different media.
- Sound obeys the same laws of reflection as light.
- Echo occurs when the original sound and its reflection(s) is/are heard distinctly.
- Reverberation is produced as a result of multiple reflections of sound reaching the listener simultaneously.
Teaching-learning of concepts related to sound could be made interesting and comprehensible through simple activities. Some exemplar activities are presented below.

**Activity 1**

**Objective:**
1. To demonstrate that sound is produced by a vibrating body.
2. To establish that sound energy is transferred from a source of sound (say a tuning fork) to the surrounding media.

- Ask students to set a tuning fork in vibration by striking its prong on a rubber pad and bring it close to their ear. What do they observe?
- Do they hear any sound?
- Let the students experience the vibrations by gently touching one of the prongs of the vibrating tuning fork with their finger.
- Bring a freely suspended plastic/thermocol ball in contact with one of the prongs of a tuning fork (i) while not vibrating and (ii) while vibrating it (Fig.1).
- Let the students observe what happens and discuss.

**Prior Knowledge Required**
- Motion of a simple pendulum and its characteristics.
- Various ways of producing sound and its propagation through a medium.
- Laws of reflection of light.
- Structure of human ear and mechanism of hearing.

**Transaction Strategy**

In place of a tuning fork, a school bell or large metal plate may also be used. Let the students observe and help them in drawing conclusion about the fact that sound is produced by vibrating objects.

Teachers may suggest students to perform the following activity also.

**Activity 2**

- Fill water in a trough/tub up to the brim. A glass/plastic container of 25 cm × 20 cm can also be used.
- Gently touch the water surface with one of the prongs of the vibrating tuning fork, as shown in Fig.2 (a). Make sure that the tuning fork is horizontal and does not touch the side of the container.
- Next dip the prongs of the vibrating tuning fork in water, as shown in Fig.2 (b). Observe what happens in both the cases. Discuss with your students why does this happen.
From above two activities teacher may help students to realize that the energy from the vibrating tuning fork is transferred to the ball or to the water surface. That is, sound energy is transferred from the source of sound (tuning fork) to the surrounding media.

**Objective:** To demonstrate that sound requires a material medium to propagate.

- Take a mobile phone. Put it in a tumbler. Ask somebody to dial the number of the phone.
- The mobile phone would start ringing. Note the loudness of the ringing sound.
- Now completely cover the opening of the tumbler with your mouth.
- Suck as much air as you can from the tumbler with your mouth and hold your breath for a few seconds. (This way you will be able to create partial vacuum inside the tumbler).
- Note what happens to the loudness of the ringing sound.
- Remove your mouth to allow air to fill the space in the tumbler.
- Note how the loudness of ringing sound changes during the entire process.

With this illustration the student can be made to realize that sound needs a material medium like air for its propagation.

**ENRICHMENT FOR THE TEACHER**

The teacher may help students to recall their experiences with toy telephone in earlier classes. Here the thread acts as material medium for propagation of sound.

**ASSESSMENT**

- Take any five objects from your surroundings. Strike them one by one using a suitable striker. Suggest way(s) to show that each one of them vibrates while producing sound.
- Sound may be produced by blowing air through a pen cap or a whistle or a bottle. Identify the material that vibrates to produce sound in these cases.
- Why was the loudness of the sound of ringing mobile decreased on sucking out the air from the tumbler in Activity – 3?

**Concept:** The propagation of sound from its source to a listener through air takes place in the form of a longitudinal wave.

The teacher may explain to the students that there are two types of waves – longitudinal and transverse.

In a longitudinal wave the individual particles of the medium oscillate about their mean positions along the direction of propagation of sound.

In transverse waves the particles of the medium oscillate about their mean positions perpendicular to the direction of propagation of the wave.

The sound propagates through air (and also other fluid media) in the form of longitudinal waves.

Nature of a longitudinal wave can be demonstrated using a slinky. Students may be asked to perform the following activity.
Objective: To demonstrate nature of longitudinal waves with a slinky.

- Fix one end of a slinky to a rigid support such as a door handle, or a window grill or a hook on a wall.
- Firmly hold the other end of the slinky and stretch it to a length until its turns are nearly 3 cm apart. The slinky may show a sag in the middle due to its weight. However, a little sagging may not affect the observations.
- At the end where you are holding the slinky, bunch together its few turns by holding them between your fingers (Fig. 3). Quickly release the compressed portion of the slinky. What do you observe? What happens to the portion (part) of the slinky which was bunched together between your fingers? Note the motion of disturbance along the length of the slinky.
- You may observe that the part of the slinky you had bunched together initially remains at its initial position while the disturbance in the form of a bunch moves along the length of slinky.
- The disturbance that moves in the form of bunch of turns along the length of slinky may be considered to be a compression.
- It can be noted that the compression moves in the same direction in which the disturbance moves. This is an example of propagation of a longitudinal pulse (Fig. 4).
- Each turn of the slinky may be considered as the particle of the medium through which the compression propagates.
- Draw attention of the students to the fact that when few turns of slinky were bunched together, the turns beyond that get stretched, that is, distance between turns increases. This stretching of turn forms a rarefaction. What happens to the stretched part when you release the coils bunched together?
- The disturbances that move along the length of slinky is in the form of a rarefaction instead of a compression.
- Now consider a case where instead of a single disturbance (or a pulse), successive train of compressions (C) and rarefactions (R) are made to propagate through a medium like a slinky. This is how a longitudinal wave propagates through a medium.

A longitudinal wave can be made to propagate along a slinky by generating a series of compressions and rarefaction in quick succession. To do so keep one end of slinky fixed and give it a few jerks in quick succession at the other end along length as shown in Fig. 5.

Teacher may ask the question-How are sound waves produced? To answer this question one may consider a source of sound, say, a vibrating tuning fork.

When the prong of a vibrating tuning fork moves to the right side from its mean position, it pushes the air particles in contact with it towards
right (Fig. 6). As a result, the particles in close proximity get compressed, that is, the density of particles or pressure increases. This is like bunching together the turns of a slinky (Fig. 4). This is called a compression. Note that when the prong moves towards one extreme and creates a compression, at the same time a rarefaction is produced on the opposite side of the prong.

It may be borne in mind that the building up of compression is a gradual process which gets completed in the time the prong takes to move from one extreme position to the other. This compression begins to move away from the tuning fork. As the prong moves backward, that is, towards its mean position and then to the other extreme it creates a region of low density of air particles or region of low pressure which is called rarefaction. This too moves away from the prong with the compression moving ahead of it. Again note that formation of rarefaction too is not abrupt but a gradual process that occurs as a continuum. As the prong of the tuning fork moves to-and-fro, a series of compression and rarefaction is created in the air. This generates the sound wave that propagates through air (medium). Ask students to explain the formation of compression and rarefaction due to a vibrating tuning fork in terms of movement of bunch of turns of a slinky through which a series of compression and rarefactions are made to move.

It needs to be emphasized that compression is the region of high pressure or higher number of air particles packed in a given volume (that is particles of the medium have high density in this region). On the other hand, rarefaction is the region of low pressure or lesser number of particles packed in a given volume. Thus, propagation of sound can be visualized as propagation of density or pressure variations in the medium. One must, however, remember that these variations are gradual and not abrupt.

Variations in density of particles of the medium or corresponding pressure changes are often represented graphically. Graph in the Fig. 7(c) shows variation in density or pressure. Values above the average density or pressure are usually taken as positive with the peak value corresponds to maximum density or pressure, that is, maximum compression. Similarly, (or pressure) are taken as negative. Obviously, maximum rarefaction values less than average density.
is represented by the lowest point of the curve. Maximum compression on the curve is often referred to as crest while the maximum rarefaction is referred to as trough.

**Interpretation of Graphical Form of a Sound Wave**

The distance between two consecutive crests or troughs represents one wavelength, \( \lambda \), of the wave. Note that this distance also represents the change in position of the vibrating prong of the tuning fork as it completes one oscillation. The frequency, \( v \), of a sound wave is the number of compressions (or rarefactions) that pass through a point in one second. It means that the distance moved by a wave in one second will be the product of its frequency and wavelength. Thus, speed, \( v \), of a wave is equal to the product of its wavelength, \( \lambda \), and frequency, \( v \), that is \( v = v \lambda \).

Like light, sound gets reflected at the surface of a solid or a liquid. The same laws of reflection are valid for sound as are for light. Reflection of sound is better if the reflecting surface is rigid and smooth. To demonstrate reflection of sound, therefore, a polished sheet of hardboard or a glass sheet can be used. While performing the activity to demonstrate that the angle of incidence is equal to the angle of reflection, in case of sound, the following activity may be performed.

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**Activity 5**

*Objective:* To verify the laws of reflection of sound

- Ask students to arrange a set-up of two plastic pipes PQ and RS as shown in Fig. 7. The pipes may be made by folding a chart paper or a sheet of newspaper if a plastic pipe is not available. The length and the diameter of the pipes may be 50 to 75 cm and 5 to 10 cm respectively. The top of the wooden table on which pipes are placed should be horizontal. Place the table close to a smooth wall. Make sure that the line ON is perpendicular (normal) to the plane of wall (Fig.8).

- Now ask students to keep a table clock close to the open end Q of pipe PQ (In place of table clock, a mobile phone on vibration mode may also be used). The angle QON is the angle of incidence \( (i) \).

- Fix vertically a sheet of thermocol along ON to prevent sound of ticking clock reaching directly to the open end S of the pipe RS. A pile of books may also be used for this purpose.

- Ask students to bring their ear close to the open end S of the pipe RS. Ask them to hear the sound of the table clock (or vibrating mobile phone) through this pipe. Do they hear any sound? Keeping the position of the end R fixed, ask them to adjust the position of pipe RS on the table so that they can distinctly hear the sound of the table clock through the pipe RS. Mark the position of end S of the pipe RS where they hear the maximum (loudest) sound. The angle NOS is the angle of reflection \( (r) \).

Students may be asked to repeat the above steps for two more angles of incidence and measure the corresponding angles of reflection. They may be asked to record these observations in tabular form and compare the values of angles i and r for each set of observation.

- Let the students analyse their data and infer the relation between these two angles.
- Do the students find \( i = r \) or the angle of incidence of a sound wave is nearly equal to the angle of reflection. If so, it means that they have verified the law of reflection, within the limits of experimental error.
• Ask students to lift the pipe RS vertically up to a small height without changing its orientation. Are they still able to hear the sound of the table clock (or vibrating mobile phone) through the pipe RS? If yes, lift the pipe to some more height. Do they still hear the sound? It will be found that on raising the height of the pipe RS, the sound of the table clock (or vibrating mobile phone) reflected from the wall either cannot be heard through pipe RS or is very feeble. This is so because now the pipe RS is not on the same plane as that of PQ or normal to the reflecting surface (wall) at the point of incidence O. This verifies the other law of reflection that is the incident sound, normal to the reflecting surface (wall) at the point of incidence and the reflected sound lie in the same plane.

ENRICHMENT FOR THE TEACHER

In this activity, it is required to hear a sound of very low intensity. It is therefore important to perform this activity at a place free from noise. It is further advised to put the fans OFF.

It is also important to have a source that can produce very clear and distinct sound. Further, in this activity two identical pipes are recommended to be used.

The pipes to be used should be of larger length having smaller diameter and a rough inner surface in order to minimise unwanted sounds.

ASSESSMENT

1. While performing Activity – 5, why do we prefer to use pipes of larger length but of smaller diameter?
2. Which type of surface would you prefer to study reflection of sound (a) a smooth wooden board, or (b) a thermocol sheet? Why?
3. Why do we require a sound of low intensity in the experiment to study reflection of sound?
4. What alterations can be made in the pipes to make the reflected sound more distinct and clear?
We are all familiar with mirrors and lenses and their uses in various fields. The laws of reflection and refraction of light provide the basis for the images formed by mirrors and lenses. In this module effort has been made to elaborate on the points which students often find difficult to comprehend.

**Key Concepts**

- Laws of reflection are universal and are valid for all surfaces whether plane or curved.
- Line joining the centre of curvature to any point on the surface of a spherical mirror is normal to the surface at that point.
- The image formed by a concave mirror could be real or virtual. The image formed by a plane or a convex mirror is always virtual.
- Size and nature of the image formed by spherical mirrors depends on the position of the object with respect to the mirror.
- Refraction of light occurs due to change in the speed of light when it enters from one medium to another.
- Refractive index for a given pair of media is determined by the ratio of speed of light in the two media.
- Image formed by a convex lens could be real or virtual whereas that formed by concave lens is always virtual.
- In case of mirrors and lenses New Cartesian Sign Convention is followed for measuring distances.
- Degree of convergenc or divergenc of light rays achieved by a lens is expressed in terms of its power.
- The magnification of an image is determined by the ratio of the size of the image and that of the object.
- The lens in human eye facilitates formation of real image of objects on the retina.
- A diverging lens of suitable focal length is used for correcting vision of persons suffering from myopia.
- A converging lens of suitable focal length is used for correcting vision of persons suffering from hypermetropia.
**Light propagates in straight line in a given medium.**

**Distinction between mirrors and lenses.**

**Laws of reflection.**

**Formation of image by a plane mirror, concave mirror and convex lens.**

**Real images can be obtained on a screen while virtual images cannot be obtained on a screen.**

**Structure of human eye.**

**Reflection of light from concave and convex mirror**

In order to make the students comprehend the image formation by spherical mirrors and lenses, it may be desirable to familiarize the students with certain basic terms given below.

**Basic Terms**

The surface of a spherical mirror can be considered to be a part of a hollow sphere. The centre of the sphere of which the mirror could be considered to be a part is termed as its centre of curvature. All points on the mirror are equidistant from its centre of curvature. This distance is known as its radius of curvature. The geometrical centre of the reflecting surface of a spherical mirror is called its pole (in case of lenses the geometrical centre of a double convex or double concave lens is called its optical centre). The line joining the pole (or the optical centre) of a spherical mirror (or a lens) and its centre of curvature(s) is called its principal axis. In case of spherical mirrors any ray which passes or appears to pass through its centre of curvature, retraces its path after reflection from the mirror. However, in case of lenses optical centre is a point through which an incident ray passes without undergoing any deviation.

The principal focus of a spherical mirror (concave/convex) is a point on its principal axis through which rays of light parallel to the principal axis will pass or appear to pass through after reflection from the mirror. Focal length of a spherical mirror is the distance between its pole and the principal focus. In case of spherical mirrors with small aperture, the principal focus is midway between the pole and centre of curvature. The diameter of the reflecting surface of a spherical mirror is a measure of its aperture. The principal focus of a spherical lens (double convex/double concave) is the point on its principal axis through which a ray of light parallel to the principal axis passes (in case of convex lens) or appear to diverge from (in case of concave lens) after refraction through it. Focal length of a lens is the distance between its optical centre and the principal focus.

**Playing With the Mirrors and Lenses**

In order to familiarize students with mirrors and lenses, a teacher may provide them opportunities to play with different types of mirrors and lenses. The teacher may guide them to see images of the objects (including their own) formed by mirrors and lenses. They may be encouraged to obtain real images of well lit objects on a screen using mirrors and lenses. They may be asked to draw the ray diagrams and also to geometrically locate the principal focus of mirror and lenses.
It is desirable that the teacher draws ray diagrams on the board and also encourages students to do so.

**Objective**: To trace the reflected ray corresponding to different incident rays parallel to the principal axis of a concave mirror and to locate its principal focus.

Draw a circle (of radius about, \( R = 25–30 \) cm (preferably with dotted line) with point C as its centre. Take a section AB of this circle as shown in Fig. 1. Darken the outer edge of this arc AB to let this arc represent a concave mirror. Mark the geometrical centre of arc as pole P of the concave mirror. The line PC represents the principal axis of the mirror. Point C is the centre of curvature of the concave mirror and the distance PC is its radius of curvature. Draw a line XY parallel to principal axis (line PC). Let this line represent a ray of light incident on concave mirror AB at point Y. The line YC would represent the normal to the surface of the concave mirror AB at point Y. The \( \angle XYC \) is the angle of incidence, \( i \), of incident ray XY. Measure this angle. According to the laws of reflection, a ray incident at an angle \( i \) with the normal will be reflected towards the other side of the normal with an angle equal to the angle of incidence. Thus draw a line YZ making an angle \( \angle ZYC = \angle XYC \), as shown in Fig. 1. The line YZ represents the reflected ray corresponding to the incident ray XY. The angle of reflection, \( r \), in this case is \( \angle ZYC \). Line YZ intersects the principal axis PC at point F.

This process of locating the reflected rays may be repeated for different incident rays parallel to the principal axis. For example line \( Y_1Z_1 \) represents the reflected ray for the incident ray \( X_1Y_1 \), as shown in Fig. 1. From the figure it can be seen that the reflected ray \( Y_1Z_1 \) also intersects the principal axis PC at point F. Students may be advised to verify this for some other rays incident on the mirror parallel to the principal axis.

This activity will make it clear that all incident rays parallel to the principal axis will pass through the point F after reflection from the concave mirror. This point F is the principal focus of the mirror. The student may be made to comprehend that the reflected ray corresponding to the incident ray parallel to the principal axis of a convex mirror appears to diverge from its principal focus.

At this stage the teacher may ask a question as to what would happen to the reflected rays if the rays of light originate from focus of a concave mirror. For this the teacher may ask the students to imagine that a point source of light is placed at the focus of a concave mirror. All the rays from this source after reflection at the mirror will be parallel to the principal axis. If you place a screen at any point beyond focus point, you may observe a patch of light. The size of this patch of light would not change if the screen is moved forward or backward with respect to the mirror. The reflectors in the head light of vehicles or a torch may also be given as examples of similar situation in which the source of light is placed very close to the focus.

The distance of focus from the pole of the mirror (PF, Fig. 1) is its focal length, \( f \). The students may also be asked to verify that \( PF = FC \). That is, the focal length of a mirror is half of its radius of curvature or \( f = R/2 \).
Locating the Image Formed by a Spherical Mirror

The teacher may apprise the students that the image formed by spherical mirrors or lenses can also be located by drawing ray diagrams. Students may also be made to realise that when an object is placed in front of a concave mirror, an infinite numbers of rays originate from each point on the object. All the rays emanating from any point on the object after reflection at the mirror pass through or appear to pass through the same point, which is the image of that point. However, in a ray diagram, it is convenient to consider only a few rays for locating the image of the point on the object under consideration. These rays are so chosen that it is easy to know their direction after reflection from the mirror. The intersection of at least two reflected rays gives the position of image of the point. In some cases, the reflected rays do not actually meet; but appear to meet at a point obtained by extending the reflected rays backwards. At this stage, the teacher may recall about the Activity - 1 in which students traced the path of the reflected ray when it was incident parallel to the principal axis of a concave mirror.

Let us consider a few situations corresponding to the reflection of light rays incident on concave and convex mirrors. Reflection of some rays which can be chosen conveniently for showing image formation in concave and convex mirrors is given below:

1. An incident ray parallel to the principal axis, passes through principal focus after reflection in case of a concave mirror [Fig. 2 (a)], and it appears to diverge from the principal focus in case of a convex mirror [Fig. 2 (b)].

2. A ray passing through the principal focus of a concave mirror [Fig. 3 (a)] or a ray which is directed towards the principal focus of a convex mirror [Fig. 3 (b)] becomes parallel to the principal axis after reflection.
3. An incident ray passing through the centre of curvature of a concave mirror [Fig. 4 (a)] or directed towards the centre of curvature of a convex mirror [Fig. 4 (b)] is reflected back along the same path.

4. A ray incident obliquely to the principal axis, on the pole of a concave mirror or a convex mirror is reflected obliquely making equal angle with the principal axis (Fig. 5).

The reflection of these rays can also be demonstrated with the help of a ray streaks apparatus (usually supplied with science kits).

Teachers may assign students the task of drawing ray diagrams for different positions of object with respect to concave and convex mirrors. This can be done by choosing any two of the four rays mentioned above. Following activity may be performed by the students to obtain the image formed by a concave mirror on a screen, when a lighted candle is placed between the centre of curvature and the principal focus of a concave mirror.

Before proceeding for the Activity-2, teacher may help students determine the approximate focal length, \( f \) of the concave mirror. This can be done by helping them to obtain a sharp image of a distant object (such as the sun or a tree or a building) on a wall or a screen and measuring the distance between the screen and the mirror. The radius of curvature \( R \) of the concave mirror may be taken as twice of its focal length \( f \). Teacher may then ask the students to proceed with the Activity-2 given below.

**Activity 2**

**Objective:** Locating the image of a candle flame placed between centre of curvature and principal focus of a concave mirror.

**Procedure:**
1. Help students to find approximate focal length of the given concave mirror.
2. Fix the mirror virtually in a mirror holder and place it near the edge of a table.
3. Mount a small candle vertically on a stand and light it. Place it in front of the concave mirror between its focus and centre of curvature (Fig. 6). Adjust the centre of the concave mirror and the flame of the candle.
such that they are at the same height. Here we shall consider the candle flame to be the object.

4. Place a screen beyond the candle. Adjust its position till a sharp image of the candle flame is obtained on the screen. Note the size of the candle flame and its image.

5. Measure the distance between the mirror and the candle and that between the mirror and the screen with a metre scale.

6. Repeat the activity for different positions of the candle beyond focus point F.

**Enrichment for the Teacher**

It is important that the flame must not flicker. Fans should be switched off so that wind does not disturb the flame. This will ensure no change in the size of the flame throughout the activity. The activity should be performed at a relatively darker place for better observations.

Now the teacher may ask the students to draw the ray diagram for the above situation by using any two of the incident rays discussed above (Fig. 7).

On the basis of the observations, make a note about —

- The position of the screen with respect to concave mirror.
- The size of image of the candle flame as compared to actual size of the flame.
- The nature of the image whether erect or inverted; real or virtual.

**Refraction of Light**

The teacher may demonstrate the bending of light when it passes from one medium to another by performing following activity.
**Activity B**

**Objective:** To show that a beam of light bends as it enters from one medium to the other medium.

**Procedure:**
- Take a beaker or a glass tumbler and fill it nearly 2/3rd with water. Add 5-6 drops of milk in it.
- Light an incense stick to create smoke above the water surface in the beaker.
- Now direct a laser beam obliquely on the surface of milky water (Fig. 8). Ask the students to observe the path of laser beam in air (made visible by smoke) and through the milky water in the beaker. Ask them to note if there is any deviation in the path of laser beam as it enters the milky water.

**Caution:** Never try to direct the laser beam to anyone's eye as it can damage the eye.

**Enrichment for the Teacher**

- If the milk added is not enough to make the laser beam visible add a few more drops until the beam becomes very clear and observable. Also note that if excess milk is added the laser beam may not be very distinct.
- Ask students to note the direction in which the beam of light deviates as it enters into water.
- Next direct the laser beam upwards from the side of the beaker and ask students to note the change in direction of the laser beam as it emerges out in air above the surface of milky water.
- After this demonstration teacher may discuss the cause of change in path of light when it enters from one medium to another.

1. How does the laser beam bend when it emerges from –
   (i) air to water and
   (ii) water to air?
2. Why do light bend when is enter from one medium to another?

**Assessment**

The Teacher should ensure that answer of students to question 2 above is based on change in speed of light in the two media.

**Locating the Image Formed by Spherical Lenses**

The image formation in case of concave and convex lenses may be introduced by following the same procedure as in spherical mirrors. In case of lenses, the most convenient rays for tracing the path of refracted ray are:

1. A ray of light, parallel to the principal axis, after refraction from a convex lens, passes through the principal focus on the other side of
the lens, as shown in Fig 9 (a). In case of a concave lens, the ray appears to diverge from the principal focus located on the same side of the lens Fig. 9 (b).

![Fig. 9: Refraction of ray parallel to principal axis.](image)

2. A ray of light passing through the principal focus, and incident on a convex lens, will emerge parallel to the principal axis after refraction [Fig. 10 (a)]. An incident ray of light that appears to meet at the principal focus of a concave lens, will emerge parallel to the principal axis after refraction [Fig 10 (b)].

![Fig. 10: Refraction of a ray which passes through/appears to pass through focus.](image)

3. A ray of light passing through the optical centre of a lens gets refracted without any deviation Fig. 11(a) and 11 (b).

![Fig. 11: Refraction of a ray passing through optical centre.](image)

The refraction of these rays can also be demonstrated with the help of a ray streaks apparatus or by using a laser beam. Here again the path of laser beam may be made visible by producing smoke on both sides of the
lens. Teachers may guide students to trace the path of laser beam incident on a lens and ask them to draw ray diagram for each case.

On the basis of the observations, for the situation shown in Fig. 12 (i.e., candle flame beyond 2f) discuss the following:

- What is the distance of the screen with respect to the convex lens? Is this less than, greater than or equal to 2f in the case of a thin convex lens?
- Is the size of the image smaller than, bigger than or same as the size of the object (i.e., candle flame)?
- What is the nature of the image formed? Is it real or virtual? Is it inverted or erect? Is it magnified (enlarged) or diminished?

Teachers may get this activity repeated for different positions of lighted candle with respect to the lens. (i.e., candle at 2f and candle between f and 2f) and discuss each case as suggested above.

Q1. A student has a convex lens and a concave lens. She wishes to obtain an image of the same size as the object. Can she do it? If yes, explain the situation with the help of a neat ray diagram.

Q2. If we wish to obtain an erect image of an object using a convex lens of focal length 20 cm. How can we do so? Explain with a ray diagram.

Activity – 5 may be performed inside a room with the help of a bright source of light to explain the concept power of a lens.
Now teacher may ask students to note if there is any difference in the distance between the lens and the screen for convex lenses of different focal length. With which lens is the convergence maximum? In which case it is minimum?

From this activity it can be concluded that convex lens with a shorter focal length has more converging effect.

Similarly, activity should also be performed with a set of concave lenses. Discuss how you will show divergence of beam of light after refraction by a concave lens.

The degree of convergence or divergence of light rays by a lens is expressed in terms of its power. Thus, the power of a lens refers to its ability to converge or diverge light rays incident on it.

(i) One can use smoke to make the path of beam of light visible before and after refraction at the lens.

(ii) In place of a torch, a beam of sunlight or two laser beams can also be used to perform this activity.

Human Eye and Its Power of Accommodation

The human eye is like a camera. Most of the refraction for the light rays entering the eye occurs at the outer surface of the cornea. The crystalline eye lens forms an image on the light sensitive retina by making finer adjustment in its focal length to focus objects at different distances. The eye lens is composed of a fibrous jelly like material. Its curvature can be modified to some extent by the ciliary muscles. The change in curvature of the eye lens can thus change its focal length. When we look at distant objects, the muscles are relaxed. As a consequence the thickness of lens reduces and its focal length increases. When we look at objects closer to the eye, ciliary muscles contract. This increases the curvature of the eye lens. The eye lens then becomes thicker. Consequently, the focal length of the eye lens decreases. This enables us to see nearby objects clearly. The ability of the eye lens to adjust its focal length is called accommodation.

Defects of Vision

We have learnt about the mechanism of how the eye enables us to see objects. We also know that the distance between the lens and the retina is fixed. In some cases, the eye may loose its flexibility, to both relax or to strain its muscles to effect desirable changes in its lens. This loss of flexibility affects the ability of the eye to effectively change focal length of its lens, that is its power of accommodation is reduced. This is one of the major cause of different types of vision problems. Nearsightedness or myopia and far sightedness or hypermetropia are two most common defects of vision.
(a) **Myopia**

A person with myopia can see nearby objects clearly but cannot see distant objects distinctly. This defect may arise due to (i) excessive curvature of the lens or (ii) elongation of the eyeball. As a result, the focal length of the eyeparts decreases and a sharp image of distant objects is formed in front of the retina and not at the retina even though muscles are relaxed. In order to see distant objects clearly, the image should be formed on the retina. This can be done by using a concave lens of suitable focal length.

(b) **Hypermetropia**

A person with hypermetropia can see distant objects clearly but cannot see nearby objects distinctly. This defect arises either because (i) the focal length of the eye lens is too long, or (ii) the eyeball has become too small. As a result a sharp image of the nearby object is formed behind the retina and not at the retina. In order to bring the image on the retina, a convex lens of suitable focal length is used.

In yet another defect of vision called presbyopia, the eye usually loses its power of accommodation. This often happens due to aging. A person suffering from this defect finds it difficult to see both nearby as well as distant objects comfortably. Such persons require a convex as well as a concave lens for correcting their vision. This is often done by using a bifocal lens. The upper portion consists of a concave lens and lower part is a convex lens.

**ENRICHMENT FOR THE TEACHER**

While explaining the defects of vision and their correction, the teacher may make students recall the concept of converging and diverging ability of lenses and power of a lens. These concepts can be used to explain the image formation in human eye and their use in correcting defects of vision.
• Optical centre of a lens is often considered to be at its geometric centre. However, double concave or double convex lenses refer to lenses with their both surfaces having equal radius of curvature. In such a case the optical centre is at the geometrical centre of the lens. Optical centre of a lens in fact, is a point through which an incident ray goes undiverted after refraction from the lens. The optical centre of a lens need not be at its geometric centre.

• The image of a distant object formed by a concave mirror is said to be formed at its principal focus. However, when the image is obtained on a screen, it is usually on the focal plane rather than at its principal focus. The focal plane is a plane perpendicular to the principal axis passing through the principal focus.

• It is a general perception that eye lens plays the major role in forming image of objects on the retina. However, most of the refraction of the light rays entering the eyes occurs at the outer surface of the cornea. The eye lens merely provides the finer adjustment of the focal length.

**Assessment**

Q.1. Which of the following concave lenses made up of the same material will have higher power? Give reason.

![Lenses](a) ![Lenses](b)

Q2. Why elderly persons often need a bifocal lens for correcting their vision?

Q3. A student sitting in the last row of the class finds difficulty in reading the board. Name the defect of vision he might be suffering from. Suggest remedial measures to enable the student to read the board comfortably.

Q4. A person finds it difficult to read a newspaper, as he cannot see the printed words distinctly. What type of defect of vision he might be suffering from? What steps should be taken to enable him to read comfortably?
Our experiences with electricity are generally related with the use of electrical appliances. Electricity is in fact flow of charges. Students at this stage are familiar with two types of electric charges and their basic properties. They are also familiar with simple electrical circuits and their components.

The existence of electric current in a circuit is perceived through one or more of its effects. These effects could be thermal (heat), magnetic or chemical. However, here we shall confine our selves to only basic concepts of electricity and its heating effect.

- Flow of charges in a definite direction constitutes an electric current.
- Electric current is measured (quantified) as the amount of charge flowing across the cross-section of a conductor in unit time.
- An electric current between two points is due to potential difference between them.
- An electric circuit provides a closed path for flow of charges, that is, the electric current.
- Electric potential difference between two points in a circuit is equivalent to the work done in carrying a unit charge from one point to another.
- Current through a metallic conductor is directly proportional to the potential difference across its ends.
- Resistance is the property of a material to resist the flow of charges through it.
- Resistance of a conductor depends on its length, area of cross-section and its material.
- Resistivity (or conductivity) of a material is its characteristic property.
- The combination of two or more resistors could be used to obtain a resistor of desired resistance.
- In a series combination of resistors, same current flows through all the resistors.
• In parallel combination of resistors, potential difference across each resistor is same.
• The electrical energy of a source in an electrical circuit gets dissipated as heat across the resistor. It is equivalent to the product of V, I and t.
• Electrical energy is expressed in kWh which is equivalent to $3.6 \times 10^6$ joules.
• Electrical energy dissipated in unit time is a measure of electric power.

Prior Knowledge Required

• Types of charges and interaction between them.
• Knowledge about simple electric circuits and their components.
• Cell (or a battery) is a source of electric current that establishes potential difference in a circuit.
• Some materials are good conductors while some are poor conductors of electric current.
• Idea of heating effect of electric current.

Transaction Strategy

1. Chemical reaction in a cell leads to excess of negative (or positive) charges on one electrode and deficiency of the same charge on the other electrode. This results in development of electric potential difference between the two electrodes of a cell.

When a cell/battery is joined in a closed electric circuit, the potential difference between its terminals causes an electric current in the circuit (or electric current starts flowing through it!).

Teachers may help students in recalling the activity done by them in previous classes of glowing a torch bulb on connecting it with a cell.

2. Students may be asked to set-up an electric circuit based on the given circuit diagram. This circuit may comprise a cell (or a battery), a resistor, an ammeter, a voltmeter and a key. While checking the circuit set-up by students, teachers must ensure that:

• the positive terminal of the ammeter is connected towards the positive terminal of the battery or the cell.
• ammeter is connected in series in the circuit.
• voltmeter is connected in parallel to the resistor and its positive terminal is connected to that end of the resistor which is connected towards the positive terminal of the battery.
• in case a battery of 6V is used, a rheostat of 20-25 ohms should be connected in series with the resistor.
• the key is connected in series in the circuit and is kept open except during the time observations are being taken or recorded.

Students may be made to realise that it is immaterial where in the circuit the ammeter and key are connected as long as they are connected in series with the resistor/cell.
**Activity 1**

**Objective:** To study the effect of variation in potential difference across the two ends of a resistor on the current through it (or to verify Ohm’s law).

- Ask students to set up an electric circuit as per the circuit diagram shown in Fig. 1 consisting of a resistor XY of about 20 ohms or so, an ammeter(A), a voltmeter(V) and four cells of 1.5 V each. In case a standard resistance of 20 Ω is not available, one can use a nichrome wire of diameter 1mm and length 20-25 cm.
- If the experiment is performed with 4 cells of 1.5V each and a resistor of 20-25 ohms, voltmeter of range (0-10V) and an ammeter of range (0-500mA) must be a preferred choice. Note the least count and zero error (with sign) of ammeter and voltmeter.
- Ask students to first use only one cell as the source of current in the circuit. Let them note the reading $I$ of the ammeter and reading $V$ of the voltmeter and record the readings in the observation table.
- Next, let students connect two cells in the circuit and note the respective readings of the ammeter and voltmeter.
- Suggest students to repeat the above steps using three cells and then four cells in the circuit separately.
- Let students determine the ratio of $V$ to $I$ for each set of observations.
- Also ask them to plot a graph between $V$ and $I$, and observe the nature of the graph.
- Does the ratio of $V$ to $I$ remain same for all values of $V$. What is nature of the graph? Is it straight line?

Now, introduce the concept of electric resistance. It is the property of conductor to resist the flow of charges through it. SI unit of resistance is Ohm or $\Omega$. It is the ratio of $V$ to $I$. Which is the slope of $V$-$I$ graph.

<table>
<thead>
<tr>
<th>S.No.</th>
<th>Number of cells used in circuit</th>
<th>Current through the nichrome wire, $I$ (mA)</th>
<th>Potential difference across the wire, $V$ (volt)</th>
<th>$\frac{V}{I}$ (volt/ampere)</th>
</tr>
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<td>1.</td>
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A straight line plot between $V$ and $I$ shows that as the potential difference across the wire increases, the current through it increases linearly. This is Ohm’s law.
Usually while computing \( \frac{V}{I} \) ratio students find that there is a deviation in the values and also all the points are not collinear on \( V-I \) graph which should pass through the origin. The teacher may clarify that in actual practice it generally happens because of the experimental errors as well limitations of the measuring instruments. However, these errors may be minimised to some extent if we observe the following precautions.

(i) Thick DCC (double cotton coated) wires should be used as connecting wires.

(ii) Both ends of the connecting wires should be properly cleaned using sand paper.

(iii) All connections should be tight.

These precautions are to be observed in all experiments pertaining to electric circuits.

Teachers may also clarify that the Ohm’s Law is valid only for conductors provided their temperature do not change.

**Objective:** To study the factors on which resistance of a conductor depends.

- Ask students to set-up an electric circuit comprising a cell or a battery, an ammeter, a nichrome wire of length \( l \) [marked (1) in Fig. 3] and a plug key as shown in Fig. 3.

  **Note:** The choice of ammeter and its range would depend on the minimum and maximum resistance in the circuit and the potential difference across its terminals. Make sure that the plug key is inserted only while taking reading.

- Now, ask students to plug the key and note the current in the ammeter.

- Ask students to replace the nichrome wire by another nichrome wire of same thickness but twice the length, that is \( 2l \) [marked (2) in Fig. 3] and note the ammeter reading.

- Next replace the wire by a thicker or thinner nichrome wire, of the same length \( l \) [marked (3) in Fig. 3]. A thicker wire has a larger cross-sectional area while a thin one has a smaller area of cross-section. Students may again note the current through the circuit.

- Now replace the nichrome wire with a wire of another material (say manganin) [marked (4) in Fig. 3] in the circuit. Ensure that this replaced wire is of the same length and has same area of cross-section as that of the first nichrome wire [marked (1) in Fig. 3]. Let the students agian note the current through the circuit.

- Encourage the students to analyse the variation in the current through the circuit in all the above four cases.

The teacher may help the student in analysing the data to draw the conclusion that the resistance of the wire in the circuit:

(i) is directly proportional to its length.

(ii) is inversely proportional to its area of cross-section.

(iii) depends on the nature of its material.
Teacher may point out that the potential difference across the resistance wire remains unchanged during the experiment. Therefore, any change in the current in the circuit is due to the change in the resistance of the wire.

On the basis of the above finding the teachers may help students in arriving at expression for the resistance of a conductor (\( R = \frac{\rho l}{a} \); where \( \rho \) is the resistivity – a characteristic of the material of conductor.) The idea of resistivity and conductivity (reciprocal of resistivity) may be introduced.

Teachers are advised to make students realise that folding a conducting wire (show by folding it) to half its length is not equivalent to doubling the area of cross-section of the wire though it may lead to the same numerical value!

**Objective:** To demonstrate heating effect of electric current.

1. Ask students to make a coil of diameter about 4 mm having 8-10 turns using a thin nichrome wire.
2. Let them set up a circuit by connecting this coil to a cell of 1.5 V through a plug key.
3. Ask students to touch the coil with their fingers before plugging the key to have a feel of its temperature.
4. Now ask students to plug the key for 10-15 seconds to pass a current through the coil. Remove the plug key.
5. Let the students touch the coil again.

What do they notice? Does the coil feel warmer now? The coil becomes hot due to heating effect of electric current.

Current through the circuit should not be passed for long duration as it may discharge the cell quickly and heat the coil to a high temperature.

Students must be asked not to hold the coil with hand after passing current through it as it may become too hot. They should be advised to feel temperature of the coil first by touching it momentarily.

Heating effect of electric current is applied in many electrical appliances used in daily life. Electric heaters, electric iron (press), incandescent lamps, fuse are some examples. The relation for heat produced \( H \) across a resistor of resistance \( R \) in time \( t \):

\[
H = VIt
\]

\[
= I^2Rt \quad \text{(for a given current through a resistor of resistance \( R \))}
\]

\[
= V^2t/R \quad \text{(for a given potential difference across the two ends of a resistor of resistance \( R \)).}
\]

This relation gives us the amount of heat or energy released in time \( t \) when a resistor \( R \) draws a current \( I \). This is also the energy dissipated by the...
source or consumed in a circuit in time $t$. Since the energy dissipated or consumed in unit time is expressed as power, $P$, therefore,

$$P = \frac{V^2}{R} \text{ or } I^2R$$

- The unit of power is watt. One watt is equivalent to the power dissipated or consumed when one ampere current flows for one second across a potential difference of one volt. Power is often expressed in the unit of kilowatt, which is equal to 1000 watt or 1 kilowatt(kW) = 1000 watt (W).

The commercial unit of energy is often expressed in unit of kilowatt hour(kWh), which is equivalent to the energy consumed (or delivered by a source) in a circuit by an appliance of power 1 kW in 1 hour.

$$1 \text{ kWh} = 1000W \times 60s \times 60s = 3.6 \times 10^6 \text{ joule}$$

**Assessment**

1. Why is it advised to plug-in the key only at the time of taking readings while studying changes in current corresponding to a change in potential difference in an electric circuit.

2. A student is given two wires A and B made of nichrome of same length $l$. Wire A is thicker than B. He is first asked to set a circuit with a cell, a key, and using wire B as resistance. The student is then asked to decrease the resistance in the circuit. Suggest any three ways of reducing the resistance in the circuit giving justification for each.
Hans Christian Oersted, a scientist of 19th century was the first to discover a relationship between electric current and magnetism. According to him whenever an electric current flows through a conductor, a magnetic field is produced around it even if it is not of a magnetic material. Later on it was found that a magnetic field is always associated with a moving charge irrespective of the nature of the medium through which it is moving.

**Magnetic Effects of Electric Current**

**Introduction**

Hans Christian Oersted, a scientist of 19th century was the first to discover a relationship between electric current and magnetism. According to him whenever an electric current flows through a conductor, a magnetic field is produced around it even if it is not of a magnetic material. Later on it was found that a magnetic field is always associated with a moving charge irrespective of the nature of the medium through which it is moving.

**Key Concepts**

- Magnetic field of a bar magnet is the region around it where its influence can be experienced.
- Magnetic field lines are closed curves, that represent the pattern of a magnetic field.
- Magnetic field due to a current carrying straight conductor is in the form of concentric circles with their centre on the conductor.
- Magnetic field at any point inside a current carrying circular loop is combined affect of field due to its each point.
- The magnetic field due to a current carrying solenoid resembles with that of a bar magnet.
- An electric current is induced in a conductor placed in a changing magnetic field.

**Prior Knowledge Required**

- Each magnet has two magnetic poles – North and South.
- Unlike magnetic poles attract whereas like poles repel each other.

**Transaction Strategy**

The pattern of magnetic field of a bar magnet can be easily perceived with a simple activity.

**Concept-1: Magnetic field and magnetic field lines of a bar magnet**

Space around a magnet where its effects is felt, is called magnetic field. Magnetic field is a quantity that has both direction and magnitude. The direction of magnetic field at a point is taken to be the direction in which North Pole of a compass needle placed at that moves due to its effect. The path along which a north pole moves freely under the influence of a magnetic field is termed as its field line. Therefore, given magnetic field can also be conceived as a definite pattern of field lines. Conventionally, the direction of field lines due to a magnet is taken from its North Pole to South Pole. However, inside the magnet, the direction of field line is from its South Pole to its North Pole. Thus the magnetic field lines are closed curves. However, it must be born in mind that magnetic field lines are imaginary line that help in comprehending the concept of field. Further
an infinite number of field lines can be drawn for any given magnetic field. Following activities may facilitate the development of above concepts.

**Activity 1**

Ask the students to take a bar magnet and keep it on the table. Place a transparent sheet say a glass sheet or a plastic sheet of about 40 cm × 20cm size over the magnet. Ensure that the sheet is stable and horizontal. Now sprinkle iron filings over that portion of the sheet below which the magnet is kept. Tap the sheet gently. At this stage the teacher may proceed with the discussion as follow:

What do you observe? Is the pattern in which iron filings arrange themselves, similar to the pattern shown in Fig 1?

![Fig. 1: Magnetic field lines of a Bar Magnet](image1)

**Activity 2**

The teacher may guide the students to set up arrangement for drawing field lines of a bar magnet with the help of a compass. Let them mark the boundary of the magnet using a sharp pencil. Ask the students to place a magnetic compass near the North Pole of the magnet and mark the positions of two ends of the needle with a sharp pencil. Now move the needle to a new position such that its South Pole occupies the position previously occupied by its North Pole. Let the students proceed step by step till the compass needle comes close to the south pole of the magnet as shown in the Fig 2. Let them join all the dots by a free hand dotted curve. This curve represents a field line.

Ask students to repeat above procedure to draw as many field lines as they can around the magnet. They will get the pattern similar to that shown in Fig. 1.

![Fig. 2: Drawing magnetic field line using a compass needle.](image2)

**Note For The Teacher**

Ask students to repeat the above steps at least two more times keeping the magnet in the same position or with different orientation. Let them observe the pattern in which the iron filings arrange themselves in each case. Initiate discussion based on their observations and help them realize that the pattern of field lines is almost similar.

The teacher may encourage the students to analyse the pattern of the magnetic field and help them to infer the following:

1. The iron filings seem to form closed curves.
2. The density of iron filings is maximum near the poles.
3. The lines formed by the iron filings do not intersect anywhere.

The teacher may initiate discussion by asking questions as suggested below:

Why do iron filings arrange in a definite pattern? What does it represent? Does the magnet influence the region surrounding it? What do the lines along which the iron filings align represent?

The discussion in the class on the above questions may help to conclude that the region around a magnet in which its force can be felt or detected is called its magnetic field. In a magnetic field a piece
of iron such as its filings, becomes a magnet due to induction. As a result pieces of iron filings behave like tiny magnets which stick to each other forming a closed curve along a field line.

The activity may be followed up by asking questions such as.
1. Do you find any similarity in the patterns obtained in the above two activities?
2. Is there any relationship between the density of field line, and the strength of magnetic field?
3. Why do field lines not intersect each other?

The teacher may at this stage tell the students about the convention followed for the directions of the field lines. That is, these are imagined to originate from the north pole and merge at the south pole.

**Concept-2 : A Current carrying straight conductor has magnetic field associated with it.**

**Activity 3**

Take a thick aluminium wire about 20 cm long and pass it through a rectangular piece of cardboard (20 cm × 20 cm). Ensure that the cardboard is held horizontal while the wire is vertical. For this purpose the cardboard may be clamped to a stand. Connect the two ends of the wire to a 6V battery through a rheostat or a resistor of 10 Ω and a key. Now, sprinkle iron filings on the cardboard. Close the key to allow a current through the wire and tap the cardboard gently (Fig. 3). Switch off the current as soon as the filings get arranged themselves in a particular pattern. Repeat the above activity for different values of current by changing the assistance in the circuit. Note the change in the pattern in each case if any.

**Note For The Teacher**

On tapping the cardboard, students may find that the iron filings start arranging themselves in a definite pattern. Ask the students to note, the shape of the pattern. Is it in the form of concentric circles around the straight wire carrying current?

A metallic wire carrying an electric current has associated with it a magnetic field. This can be demonstrated by Activity-3.

Based on the above observations help students realise that:

- The field associated with a current carrying straight conductor is in the form of concentric circle with their centre at the conductor.
- The pattern of the magnetic field is independent of the strength of current.

Discuss with the students, what do concentric circles of the iron filings indicate?

Alternately, to observe the direction of the field lines arrange 7-8 compass needles around the straight conductor. Now switch on current through
the conductor. The deflection of the compass needles shows the direction of the magnetic field line. Now reverse the direction of the current. Does the direction of the magnetic needle, i.e., magnetic field lines also get reversed?

**Activity 4**

Ask the students to arrange another set of compass needles in the form of a circle of comparatively bigger radius around the straight conductor as in Activity 3. Pass the same current through the conductor as before. Observe whether the magnetic needles align themselves along the circles of two different radii, one larger than the other. Then proceed with the discussion as given below:

Do you observe any difference in the deflection of the needles in two sets when current is passed through the conductor? What conclusion do you draw from it? Do the concentric circles intersect each other anywhere? Now ask the students to increase the current in the circuit and observe the change, if any, in the concentric circles. Discuss giving justification for each observation.

**Note For The Teacher**

- The above activity cannot help us to establish any quantitative relationship.
- At this stage, the teacher may help the students to realize that the direction of the magnetic field produced due to a current-carrying straight conductor can be determined by the right hand thumb rule. Ask the students to verify this in the above activity.

**Concept–3:** Magnetic field due to a current carrying circular loop.

The pattern of the magnetic field around a conductor due to an electric current flowing through it may change if the conductor is in the form of a circular loop. The magnetic field due to a current flowing through a circular loop can be demonstrated by following activity.

**Activity 5**

Ask the students to take a loop of thick aluminium wire of about 10 cm in diameter on a piece of thick cardboard sheet of size 20 cm × 20 cm as shown in Fig 4. In case the arrangement with loop fixed on a cardboard is not available, the teacher may guide students to prepare their own set up. The teacher may help students to cut two slits up to the middle of the piece of cardboard from one of its sides. The distance between the slit should be equal to the outer diameter of the loop. Next, slip the loop through the slits to fix it in the middle of the cardboard. The slits thereafter can be covered with a tape.

![Fig. 4: Magnetic field due to current flowing through a circular loop](http://www.foxitsoftware.com)

Ask the students to connect the two ends of the loop to a 6V battery through a rheostat or 10 Ω resistor and a plug key. Sprinkle iron filings on the cardboard sheet uniformly all around the coil. Now close the plug key and gently tap the board. Observe carefully what happens to the iron filings. Students may observe that the filings arrange themselves in a definite pattern. When it happens ask the student to immediately open
the circuit by removing the key from the plug. The pattern so obtained may be considered as the magnet field pattern associated with the current carrying loop. Ask the students to observe the field pattern at a point (i) near the loop and (ii) near the centre of the loop.

Teacher may proceed with discussion through questions as follows: How do the field lines look like? Do you observe concentric circles of larger and larger radii around the two arms of the loop that cut through the cardboard? How does the pattern of the field lines look like at the centre of the loop? Is it straight? What do you conclude from it? Do you think every small element of the current carrying loop contributes to the magnetic field? Justify your answer. How can you find the direction of magnetic field at a point?

**Concept-4: Magnetic field due to a current carrying solenoid.**

A solenoid is a coil of many circular turns of insulated copper wire wrapped closely in the shape of a cylinder. The nature of magnetic field due to solenoid can be demonstrated by the following activity.

**Activity 6**

The teacher may guide the student to fix a solenoid of about 10 cm length and 5 cm diameter by winding wire of copper through the holes in a stiff cardboard as shown in Fig 5. Alternately, a solenoid could be fixed on to the cardboard following a procedure similar to as suggested in the Activity-5. Connect the two ends of the solenoid to a battery of 6 V through a rheostat or resistor of about 10 Ω and a key. Sprinkle some iron filings on the cardboard. Now close the plug key to pass current through the solenoid and tap the cardboard gently. Observe what happens to the iron filings. The pattern in which the iron fillings arrange themselves represent the field lines of the current carrying solenoid. Observe this pattern (i) near the two ends, (ii) outside the solenoid along its length on both sides, and (iii) inside the solenoid. Now the teacher may proceed with discussion through questions as follows. Have you seen similar pattern of the field lines earlier? What do you think about the strength of the magnetic field at different points around the solenoid? Does it vary around the solenoid? What does the pattern of parallel lines inside the solenoid suggest about the nature and strength of magnetic field? Is the magnetic field uniform inside the solenoid?

Based on the observations and inference made in the above activity help the students conclude that —

- One end of a current carrying solenoid behaves as a north pole and the other as a south pole like that of a bar magnet.
- Field lines inside the solenoid are parallel and equidistant suggesting that the field inside a current carrying solenoid is uniform.

**Concept-5: Electromagnetic Induction.**

The phenomenon of the production of induced current in a coil placed in a region where magnetic field changes with time is called electromagnetic induction. This can be demonstrated by the Activity - 7.
The teacher may ask the students to carefully observe the needle of the galvanometer when the magnet is being moved towards or away from one end of the solenoid. At this stage discussion may be initiated by asking the following questions:

• What do you observe when N-pole of the magnet approaches one end of the solenoid?
• What happens to the magnetic field linked with this end of the solenoid when N-pole of the magnet approaches it?
• What do you think is the reason for the deflection of the galvanometer needle?
• Do you observe any deflection in the galvanometer if the magnet is held stationary inside the solenoid or near its end?
• Does the deflection depend on the speed with which magnet is moved towards or away from the solenoid?

Here the teacher may introduce the idea of induced current. The teacher may ask the students to bring one by one the north and south pole of the magnet towards or away from one end of the solenoid and note the direction of the deflection of the galvanometer needle in each case and continue the discussion with following questions:

• What is the direction of the induced current when (i) north pole and (ii) south pole of the magnet is brought towards one end of the solenoid?
• Is there any difference between the induced current and the current that flows through this solenoid when connected to a battery?
• What would happen if the magnet is held stationary and the solenoid is moved towards the magnet? Try it.
• What can be concluded from the above observations?
• Can we use this phenomenon to generate electricity?
• A magnetic field is said to be uniform over a region if it has same magnitude and direction at all points in that region.
• Magnetic poles always exist in pairs i.e. north pole is always accompanied by a south pole and vice versa. If you cut a magnet in two or more pieces, you get as many complete magnets as the pieces are.

• Electric motors, generators, loudspeakers, mixers, computer disk drives, hearing aids, metal detectors are some of the devices that require magnetic field to operate.

• A solenoid is a coil of many loops (turns) of insulated conducting wire wrapped in the form of a cylinder whose length is comparatively larger than its diameter. Magnetic field lines produced by a current carrying solenoid are similar to that of a bar magnet.

• DCC (Double Cotton Coated) wires have two layers of cotton thread wound around them for insulation and are quite convenient for low voltage. These wires are commonly used in laboratories as connecting wires. Heavy currents should not be passed through these wires as they may become hot or even catch fire.

**Assessment**

1. Why do the field lines in Activity-3 not intersect each other?
2. If 5 strands of wire are used instead of one long straight conductor, will there be any change/changes in the pattern of the field lines if a current is passed through it. Justify your prediction.