Based on the latest CBSE syllabus

9

LIVING SCIENCE
CHEMISTRY

Arun Syamal

Ratna Sagar

Based on the latest syllabus and guidelines issued
by the Central Board of Secondary Education (CBSE)

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CHEMISTRY

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Arun Syamal
MSc, PhD, DSc
Formerly Chairman, Professor of Chemistry and Director,
National Institute of Technology (Deemed University), Kurukshetra, Haryana

Ratna Sagar

ABOUT THE AUTHOR

Dr Arun Syamal, MSc, PhD, DSc, formerly Chairman, Professor of Chemistry and Director of National Institute of Technology, Kurukshetra, Haryana has a vast experience in teaching and has been a paper-setter for various school board examinations. He is the author of many books.

Dr Syamal has published about 350 scientific research papers, some of which are in the field of improvement of science education at the high school level. He has received awards from American Chemical Society for his contribution towards the development of science and technology in the last four decades. He has also received two awards from Indian Chemical Society for his researches in Chemistry. He was a Research Associate at Texas State University, Denton, Texas, USA and Emory University, Atlanta, Georgia, USA from 1968 to 1973.

When you can measure what you are speaking about, and express it in numbers, you know something about it; but when you cannot express it in numbers, your knowledge is of a meagre and unsatisfactory kind; it may be the beginning of knowledge, but you have scarcely, in your thoughts, advanced to the stage of Science, whatever matter may be.

— Lord Kelvin

This book is dedicated to my late parents.

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VIRAT BHAVAN, COMMERCIAL COMPLEX, MUKHERJEE NAGAR, DELHI 110009
PHONE: (011) 47038000 ◆ FAX: (011) 47038099
rsagar@ratnasagar.com ◆ ratnasagar.com ◆ ratnasagar.co.in
SHOWROOM: 4808/24 BHARAT RAM ROAD, DARYA GANJ, NEW DELHI 110002
PHONE: (011) 43028000 ◆ FAX: (011) 45166099

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Preface

It has been a real pleasure to note the response with which the first revised edition has been received. It gives me immense pleasure in presenting Living Science Chemistry for Class IX written strictly in accordance with the latest NCERT syllabus woven with the latest CBSE guidelines aimed at the holistic assessment of the learners.

Salient Features of the Book

- This book contains Let Us Revise, Check Your Progress, Activities, Chapter-end Exercises, etc. in each chapter to develop cognitive, psychomotor and affective domains of learning and lays emphasis on scientific thought process.
- **Practice Questions:** Each chapter has Practice Questions at the end. It measures or 'sums-up' how much a student has learnt from the chapter. It is a graded assignment consisting of the questions based on knowledge, understanding, application, analysis, synthesis and evaluation type of questions. The following types of questions have been included in practice questions:
  - Very Short Answer Type (VSA) questions (one-mark each)
  - Short Answer Type-I (SA-I) questions (two-marks each)
  - Short Answer Type-II (SA-II) questions (three-marks each)
  - Long Answer Type (LA) questions (five-marks each)

  Due weightage has been given to
  - Higher Order Thinking Skills (HOTS) questions
  - Value-Based Questions
  - Passage-Based Questions
  - Questions Based on Practical Skills in Science

Constructive criticisms and suggestions from teachers and students for the improvement of this book are most welcome. Lastly, I hope you will enjoy reading this book as much I have enjoyed writing it. Do email your feedback.

email: arunsyamal@hotmail.com
D 708, Ushanagar, Bhandup, Mumbai

Arun Syamal

Remodeled Assessment Structure

(Based on CBSE Circular No.: Acad-05/2017 dated 31/01/2017)

1. SCHOLASTIC AREA

	Total 100 marks (Syllabus for assessment will be only Class-X)			
Subjects	**80 Marks** **(Board Examination)** Student has to secure 33% marks out of 80 marks in each subject	**20 Marks** **(Internal Assessment)** Students has to secure 33% marks out of overall 20 marks earmarked in each subject		
		Periodic Test (10 Marks)	Notebook Submission (5 Marks)	Subject Enrichment Activity (5 Marks)
		(i)	(ii)	(iii)
Language 1	Board will conduct Class-X Examination for 80 marks in each subject covering 100% syllabus of the subject of Class-X only. Marks and Grades both will be awarded for individual subjects. 9-point grading will be same as followed by the Board in Class XII.	Periodic written Test, restricted to three in each subject in an Academic Year. Average of the best two tests to be taken for final marks submission.	This will cover: ❖ Regularity ❖ Assignment Completion ❖ Neatness & upkeep of notebook	Speaking and listening skills
Language 2				Speaking and listening skills
Science				Practical Lab work
Mathematics				Maths Lab Practical
Social Science				Map Work and Project Work

(i) Periodic Test (10 marks)

The school should conduct three periodic written tests in the entire academic year and the average of the best two will be taken. The schools have the autonomy to make its own schedule. However, for the purpose of gradient learning, three tests may be held as one being the mid-term test and other the two being pre-mid and post mid-term with portion of syllabus cumulatively covered. The gradually increasing portion of contents would prepare students acquire confidence for appearing in the Board examination with 100% syllabus. The school will take the average of the best two tests for final marks submission.

(ii) Notebook Submission (5 marks)

Notebook submission as a part of internal assessment is aimed at enhancing seriousness of students towards preparing notes for the topics being taught in the classroom as well as assignments. This also addresses the critical aspect of regularity, punctuality, neatness and notebook upkeep.

(iii) Subject Enrichment Activities (5 marks)

These are subject specific application activities aimed at enrichment of the understanding and skill development. These activities are to be recorded internally by respective subject teachers.

For Languages: Activities conducted for subject enrichment in languages should aim at equipping the learner to develop effective speaking and listening skills.

For Mathematics: The listed laboratory activities and projects as given in the prescribed publication of CBSE/NCERT may be followed.

For Science: The listed practical works/activities may be carried out as prescribed by the CBSE in the curriculum.

For Social Science: Map and project work may be undertaken as prescribed by the CBSE in the curriculum.

2. CO-SCHOLASTIC ACTIVITIES

Schools should promote co-curricular activities for the holistic development of the student. These activities will be graded on a 5-point grading scale (A to E) and will have no descriptive indicators. No upscaling of grades will be done.

Activity	To be graded on a 5-point scale (A–E) in school	Areas and Objectives (as prescribed in the Scheme of Studies for Subjects of Internal Assessment)
Work Education or Pre-Vocational Education	By the concerned Teacher	Work education is a distinct curricular area for students for participation in social, economic and welfare activities. Student gets a sense of community service and develops self-reliance. (for Pre-Vocational Education as per Scheme of Studies)
Art Education	By the VA/PA or the concerned teacher	Art Education constitutes an important area of curricular activity for development of wholesome personality of the students. Students will select one or more forms of creative arts.
Health & Physical Education (Sports/ Martial Arts/Yoga/ NCC, etc.)	By the PE Teacher	Health & Physical Activity preferably sports must be given a regular period. Students should be provided opportunities to get professionally trained in the area of their interest. Indigenous sports, yoga and NCC must be encouraged in the schools creating a sense of physical fitness, discipline, sportsmanship, patriotism, self-sacrifice and health care.

3. DISCIPLINE (Attendance, Sincerity, Behaviour, Values)

Discipline significantly impacts career shaping and it helps build character. Sincerity, good behaviour and values develop strength and foster unity and cooperation. Therefore, the element of discipline has been introduced. Class teacher will be responsible for grading the students on a Five-point scale (A to E).

The internal assessment comprising 20 marks (10 + 5 + 5) entails objectivity and a structured approach. For a holistic assessment, the teachers are expected to make it an effective tool.

B. DOCUMENTATION

Records pertaining to the internal assessment of the students done by the schools will be maintained for a period of three months from the date of declaration of result for verification at the discretion of the Board. Subjudiced cases, if any or those involving RTI/Grievances may however be reatined beyond three months.

C. ASSESSMENT SCHEME FOR CLASS VI TO IX IN THE CBSE AFFILIATED SCHOOLS

The CBSE affiliated schools, for the purpose of uniformity in classes VI to IX may, replicate the same assessment model as described above for Class X.

The above scheme must be implemented in letter and spirit.

Contents

"Chemistry is the science of molecules and their transformations."

— ROBERT HOFFMAN

CHAPTER 1

Matter in Our Surroundings

Learning Objectives

- Different kinds of materials
- Materials in our clothing
- Cooling by evaporation
- Absorption of heat by materials
- All things occupy space, possess mass
- Definition of matter
- Physical classification of matter
- Solids, liquids and gases
- Characteristics of matter – shape, volume, density
- Change of state – melting, freezing, evaporation, condensation, sublimation

The universe is made up of matter and energy. While the transformation of matter to energy can be seen, the transformation of energy to matter cannot be seen. The discovery of relationship between energy and matter ($E = mc^2$), and of interaction between energy and matter has been of lasting importance. These processes occur in nature and in our daily life at every moment. In order to know more about these interrelationships and the proper utilisation of energy for the benefit of mankind, and to know the world around us, we need to know about the matter in greater detail. Everything in this universe is made up of matter. Matter existed on the earth even before the first man had appeared on it. Matter occupies space and has definite amount of mass.

MATERIALS

The matter from which a thing is made is called material. Material exists in different shapes, sizes and textures. The examples of material are cloth, fabric, wood, sand, rock, water, air, plastic, rubber, leather, food, etc. There are different kinds of materials such as building materials (e.g. brick, cement, lime, rod, glass, paint, etc.), cleaning materials (e.g. soaps, detergents, etc.), writing materials (e.g. paper, pencil, pen, ink, etc.), engineering materials (e.g. water, plastic, rubber, steel, etc.), sports materials (e.g. racket, bat, ball, sports shoe, etc.), food materials (e.g. oil, sugar, spice, rice, egg, etc.), kitchen materials (e.g. kettle, saucepan, pressure cooker, etc.), medical materials (e.g. medicine, rectified spirit, medical cotton, etc.), clothing materials (e.g. cotton, terrycot, terrywool, polyester, nylon, etc.).

Materials like rock, water and air are very different from each other. When a piece of rock is kept on a table, it stays there. When water is poured on a table, it flows. We can see rock and water. But we cannot see air. We can feel air moving around us, specially when it is windy. Rock, water and air are alike in the sense that they all occupy space and have mass.

Is there some similarity between materials?

There are certain ways in which some materials are alike. For example, plastic and leather look different and they are used for different purposes, but both have some similarities as well.

MATTER

Matter is defined as something which occupies space, possesses mass and offers resistance to

any stress applied on it. The examples of matter are innumerable. A few of them are: water, milk, sugar, wood, plastics, rubber, gold, iron, clothes, air, petrol, kerosene oil, alcohol, vegetable oil, etc. Different kinds of matter are made up of different substances. Matter varies in size, e.g. small objects [elementary particles present in an atom (diameter of elementary particles = 10^{-15} m), atoms (diameter = 10^{-10} m), molecules (diameter = 10^{-9} m), cell (diameter = 10^{-6} m)] as well as very large objects [e.g. galaxies (diameter = 10^{20} m), universe (diameter = 10^{26} m)].

Different matters have different physical state, colour, shape, smell, etc. which can be felt through one or more of our sense organs. They differ in their capacity to conduct heat and electricity. They also differ in mechanical strength – some are hard, some are soft and some break easily. For example, steel is very hard but glass is breakable. Foam is very soft. Some matters float in water (e.g. cork, ice) while some matters sink in water (e.g. stone, steel).

Different matters have different mass. The mass of a matter in a substance can be very less [e.g. electron (mass = 10^{-31} kg), atom (mass = 10^{-26} kg)] as well as very high [e.g. planets (mass = 10^{30} kg), galaxies (mass = 10^{40} kg)].

Particulate nature of matter

The nature of matter can be ascertained by studying its properties and composition. The physical properties of a matter can be observed or measured without changing its composition. The physical properties of a matter basically mean its colour, smell, density, melting point, boiling point, etc. The particulate nature of matter can be tested by conducting the following experiments.

Activity 1

Showing the particulate nature of the matter

Take 50 mL of water in a 100 mL beaker and mark the level of water. Add about 2 g of sugar into the beaker and stir with the help of a glass rod till all the sugar dissolves (Fig. 1.1). Does the water level in the beaker change? Taste a drop of this solution. How does it taste? Are the crystals of sugar visible in the solution? The answers to these questions are as follows:

1. The water level in the beaker remains the same.
2. A drop of the solution tastes sweet.
3. The sugar crystals are not visible in the solution.

Matter consists of small particles. In between these small particles, there exists empty spaces between particles called **voids**. When sugar is added to water, the particles of sugar occupy the empty spaces between the particles of water. This leads to dissolution of sugar in water. It is concluded that the particles of matter have spaces between them.

What happens to the crystals of sugar as they are not visible? Let us conduct some more experiments.

Activity 2

Showing the particulate nature of the matter

Take a small pink crystal of potassium permanganate ($KMnO_4$) in a 500 mL beaker. Add 400 mL of water

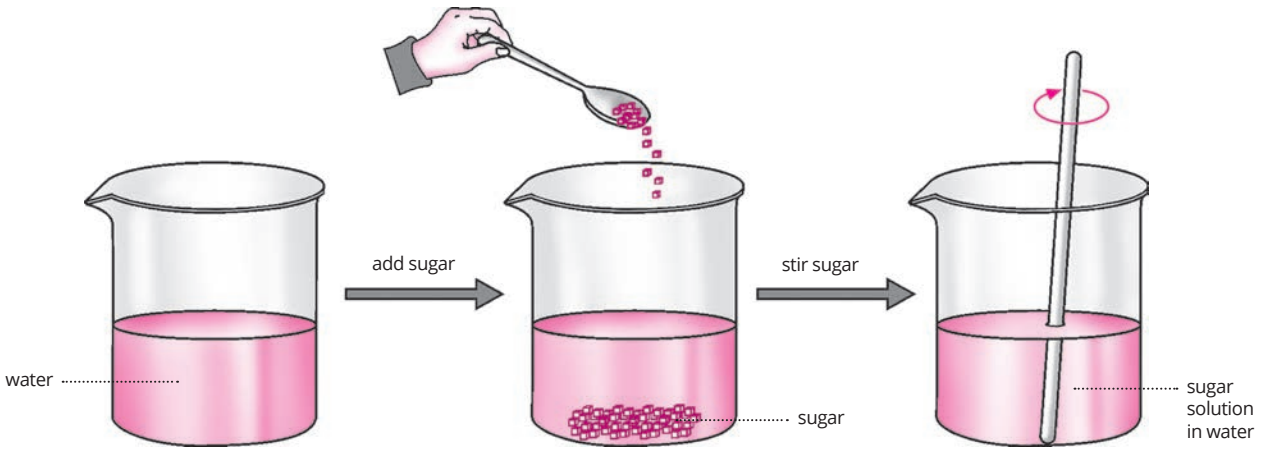


Fig. 1.1 Dissolution of sugar in water

slowly by the wall of the beaker. Allow the beaker to stand undisturbed (Fig. 1.2). Observe the spreading of pink colour in the water. The whole solution turns pink after several hours. Why?

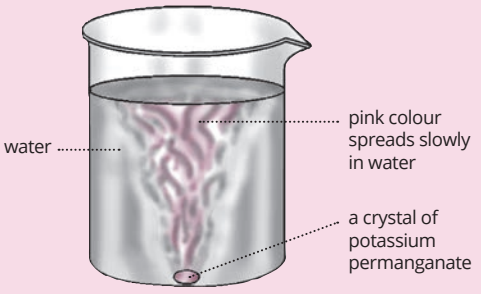


Fig. 1.2 Dissolution and spreading of potassium permanganate in water

Activity 3

Showing the particulate nature of the matter

Take 400 mL of water in a 500 mL beaker. Add a drop of blue ink to water in the beaker without disturbing the beaker and water. Allow the beaker to stand undisturbed. Observe the spreading of blue colour in the water (Fig. 1.3). The whole solution turns light blue after several hours. Why?

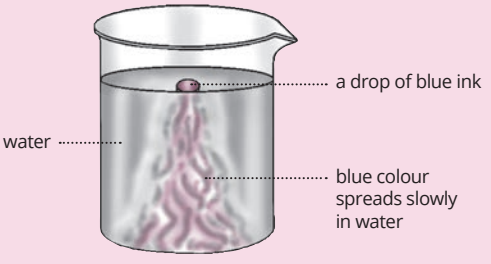


Fig. 1.3 Dissolution and spreading of ink in water

We conclude the following from the above activities:

1. Sugar, potassium permanganate and ink get uniformly distributed in water.
2. Just one crystal of potassium permanganate or one drop of ink can change the colour of a large volume of water.
3. The matter in sugar, potassium permanganate and ink gets divided into smaller particles to spread in the whole water. These particles cannot be seen even with a powerful microscope.
4. There might be millions of tiny particles in just one crystal of potassium permanganate or sugar or one drop of ink.
5. There is enough space between the particles of matter. The particles of sugar, potassium permanganate or ink get distributed into the spaces between the particles of water.
6. Particles of matter are continuously moving.

Hence, the above experiments show that all forms of matter consist of small particles, the particles of matter have space between them and the particles of matter are continuously moving.

Diffusion of matter

The intermixing of particles of two or more different substances on their own is called diffusion. Some examples of diffusion are:

1. The aroma of burnt incense sticks can be felt from a distance because of diffusion of smoke particles in the air around.
2. The fragrance of perfumes can be felt from a distance because of diffusion of vapours of perfumes in the air around.
3. The odour of the food being cooked in the kitchen can be known without even entering into the kitchen.

The rate of diffusion of gases is very high because the particles of gases travel with high speed. The rate of diffusion increases with increase in temperature. This is because with increase in temperature the kinetic energy of the particles increases and the particles move faster. The lighter gases diffuse faster than the heavier gases. The diffusion of a solid into another solid substance is negligible due to the immobility of particles in solids. The diffusion of a liquid into another liquid and that of a solid into a liquid is much slower than the diffusion of a gas into another gas.

How small are the particles of matter?

Matter is made up of extremely small-sized particles. We shall prove this from the following experiment.

Activity 4

Smallness of the particles of matter – getting an idea

Dissolve one crystal of potassium permanganate in 10 mL of water taken in a 500 mL beaker. Now fill

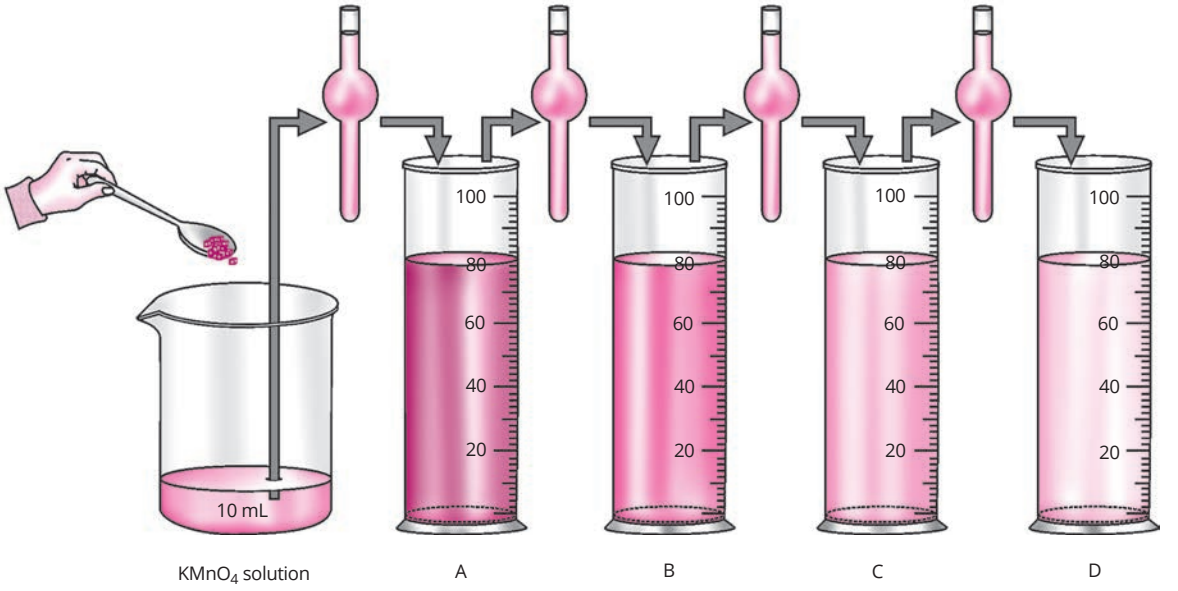


Fig. 1.4 Getting an idea of smallness of particles of matter. The colour of potassium permanganate ($KMnO_4$) solution gets lighter with dilution. The colour of $KMnO_4$ solution is still visible in the cylinder D.

80 mL of water in each of four 100 mL measuring cylinders (A, B, C, D) (Fig. 1.4). Transfer the potassium permanganate solution to the measuring cylinder A with the help of a pipette. Stir the solution with a glass rod so that the contents mix thoroughly. Transfer 10 mL of this solution to the measuring cylinder B. Stir this solution thoroughly. Transfer 10 mL of this solution to the measuring cylinder C, stir this solution thoroughly. Transfer 10 mL of this solution to the measuring cylinder D. Stir this solution thoroughly. Compare the colours of solutions in all the measuring cylinders. We observe that the solution remains coloured even at very high dilution (measuring cylinder D), although the intensity of the colour of the solutions decreases with dilution.

Do the same activity using 2 mL of dettol instead of potassium permanganate. The smell of dettol is detected even after repeated dilution.

We conclude the following from the above experiment (Activity 4):

1. A crystal of potassium permanganate contains a very large number of very small particles, which keep on dividing into smaller and smaller number with each dilution. As a result, the colour becomes lighter after each dilution.
2. Even at very high dilution, the particles exhibit the properties of potassium permanganate.

If we go on diluting the solution in this manner, a stage will be reached ultimately when the particles cannot be divided further. Matter is made up of extremely small particles which cannot even be seen with a powerful microscope. With a powerful microscope, we actually see an aggregate of tiny particles.

The smallest particle of a matter which is capable of independent existence and which exhibits the properties of matter is called **molecule** of that matter. The diameter of the molecules of matter, in general, is of the order of 10^{-9} m. Now you know how small the particles of matter are.

Activity 5

Demonstrating that the particles of matter are continuously moving

Put an unlit incense stick in a corner of the class. Find out how close you have to go near the incense stick so as to get its smell. Record your observation. Now light the incense stick with the help of a matchstick. What happens to the smell? Do you get the smell at a distance from the incense stick? Record your observation.

The particles of matter are continuously moving and they possess some kinetic energy. When the temperature is increased, the kinetic energy of the particles increases and the particles move faster. In the case of unlit incense stick, the temperature is low and the kinetic

energy of the particles of incense is low. Under this condition, the particles of incense do not mix with the particles of air rapidly. Due to this we have to go very near to the incense stick to get the smell of its particles. When the incense stick is lit, the temperature increases leading to the increase of kinetic energy of the particles of incense. As a result, the particles of incense move very rapidly and they intermix with the particles of air very rapidly. This is the reason we get the smell of particles of incense even when we are at a distance from the unlit incense stick.

It is concluded that the particles of matter are moving continuously and the particles of matter intermix on their own with each other. When temperature increases, the kinetic energy of particles of matter increases and hence, they move even faster.

Activity 6

Demonstrating that the rate of intermixing depends upon the forces of attraction between the particles of matter

Take two beakers filled with water. Put a drop of red ink slowly and carefully along the side of the first beaker. Put a drop of honey along the side of the second beaker. Leave the two beakers undisturbed in a corner of the class. Record your observations.

1. What did you observe immediately after adding the ink drop?
2. What did you observe immediately after adding the drop of honey?
3. How many hours or days does it take for the colour of the red ink to spread evenly throughout the water?

It is observed that the ink drop moved rapidly and the drop of honey moved slowly. The ink drop moved rapidly because the forces of attraction between the particles of red ink are weak. The drop of honey moved slowly because the forces of attraction between the particles of honey are strong. Hence, it takes longer time for the particles of honey to occupy the spaces between the particles of water and get evenly distributed throughout the water.

It is concluded that the particles of matter are moving continuously. The average speed of particles of matter at any particular temperature depends on the intermolecular attractive forces. The stronger the intermolecular attractive forces, the lower is the average speed of the molecules.

Activity 7

Demonstrating that the rate of intermixing of particles of matter increases with increase in temperature

Drop a crystal of copper(II) sulphate pentahydrate or potassium permanganate into a 250 mL beaker containing hot water and another 250 mL beaker containing cold water. Do not stir the solutions. Allow the crystals to settle at the bottom of the beakers.

1. What do you observe just above the solid crystal in the beaker?
2. What happens to the crystal as time passes?
3. What does this suggest about the particles of solid and liquid?
4. Does the rate of mixing change with temperature? Why and how?

It is observed that the particles of water lying immediately above the solid crystal start acquiring blue colour due to the dissolution of copper(II) sulphate pentahydrate or purple colour due to the dissolution of potassium permanganate. With the passing of time, more and more particles of copper(II) sulphate pentahydrate or potassium permanganate dissolve in water and the colour starts deepening and spreading into more water. Finally, the whole solution becomes coloured. In solid, there exists strong interparticle forces of attraction. As a result, the particles of a solid remain fixed in their respective positions and the kinetic energy of particles of a solid is almost zero.

In a liquid, there exists weak intermolecular attractive forces. As a result, the particles of a liquid (e.g. water) are moving continuously and they possess some kinetic energy even in the cold. Due to the presence of kinetic energy, the particles of a liquid (e.g. water) overcome the interparticle forces of attraction that exists between the particles of a solid. Hence, the particles of water occupy the space in between the particles of the solid. As a result, there occurs dissolution of crystal in cold water. With the passing of time, more and more particles of crystal dissolve in water and the colour starts deepening and spreading into more water. Finally, the whole solution becomes coloured.

It is observed that with the increase of temperature the crystal dissolves more rapidly in hot water. The kinetic energy of both solid and liquid particles increases with increase in temperature. As a result, at higher temperature the forces of attraction between the solid particles become weak. At higher temperature, the particles of liquid move faster. As a result, the particles of liquid overcome more easily the weak forces of

attraction between the particles of solid. Hence, at higher temperature the rate of intermixing of particles of solid and liquid increases and the solid dissolves more rapidly in hot water than in cold water.

Activity 8

Demonstrating that the particles of matter attract each other

Open a water tap and adjust it so that the flow of water is moderate. Try to break the stream of water with your index finger. Record your observations and reason:

1. Whether you were able to cut the stream of water with your index finger.
2. Suggest the reason behind the stream of water remaining together.

When we try to cut the stream of water with fingers, the stream of water cannot be cut since the particles of water attract each other strongly. Hence, the stream of water tends to remain together. It is concluded that the partciles of matter attract each other.

Activity 9

Finding out the relative strength of intermolecular attractive forces in some matter

Take a piece of chalk, a rubber band and an iron nail (about five inch length). Try to break these materials by cutting with a knife, stretching or hammering. Record your observations regarding the material in which the particles are held together with greater intermolecular attractive forces.

It is very difficult to break the iron nail and hence the particles of iron nails are held together by very strong intermolecular attractive forces. The strength of the intermolecular attractive forces is weaker in chalk. The particles of rubber band are held by the weakest attractive forces. It is concluded that the particles of matter attract each other and the strength of attractive forces differ from one kind of matter to the other.

Activity 10

Studying the properties of solid

Collect the following articles: a book, a pen, a needle, a piece of thread. Sketch the shapes of these articles in your notebook by moving a pencil around them. Find out whether all these articles have a definite shape, distinct boundaries and a fixed volume. What happens if these articles are hammered, pulled or dropped? Find out whether these articles are capable of diffusing into each other. Try to compress the articles by applying force. Record your observations.

All these articles are solid since these articles are rigid, are not compressible and they have a definite shape, distinct boundaries and fixed volumes.

Particles of matter attract each other

We have learnt that a substance contains a very large number of small particles. How are these particles held together? These small particles are held together by strong intermolecular attractive forces. These forces keep the particles together and the strength of these forces varies from one kind of matter to another. The intermolecular attractive forces in matters are in the order:

gas < liquid < solid

LET US REVISE

- **Matter** is defined as something which occupies space, possesses mass and offers resistance to any stress applied on it.
- The matter from which a thing is made is called **material**.
- Matter is made up of extremely small-sized particles.
- The intermixing of particles of two or more different substances on their own is called **diffusion**.
- The smallest particle of a matter which is capable of independent existence and which exhibits the properties of matter is called **molecule** of that matter.
- The small particles of matter are held together by strong intermolecular attractive forces.

CHECK YOUR PROGRESS

1. Describe an experiment to show the particulate nature of matter.
2. Where does potassium permanganate go when a crystal of potassium permanganate is dissolved in water?
3. Define diffusion. Give one example of diffusion.
4. How small are the particles of matter?
5. Describe an experiment to show the smallness of the particles of matter.
6. What are the characteristics of the particles of matter? **(Textbook Question)**

ANSWERS

6. The characteristics of particles of matter are: **i.** They have space between them. **ii.** The particles of matter are continuously moving. **iii.** The particles of matter are very small. **iv.** The particles of matter attract each other.

Ancient Indian and Greek philosophers in and around 400 BC thought matter was made up of five basic elements, the *panchtatva* – air, earth, water, sky and fire. Our present day knowledge considers nature in terms of matter and energy. We now classify matter in terms of their physical and chemical properties.

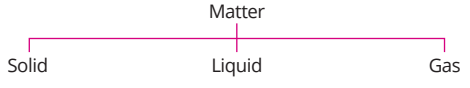
CLASSIFICATION OF MATTER

All substances exhibit some physical and chemical properties. The physical properties of a substance describe its physical state, shape, softness or hardness, melting point and boiling point, etc. The chemical properties describe the ability of a substance to change into new substance or substances. On the basis of physical and chemical properties, matter is classified as follows:

1. Physical classification of matter
2. Chemical classification of matter

Physical classification of matter

On the basis of physical properties of matter, it is classified into three states, namely, solid, liquid and gaseous states.



The three states of matter arise due to the differences in interparticle distances, differences in interparticle forces of attraction and differences in kinetic energies of the constituent particles.

- **Solid state:** In the solid state, the particles are bound together by strong interparticle attractive forces, and are closely packed. This makes solids hard and rigid. A solid possesses definite volume and definite shape. Some common examples of solids are iron, gold, stone, wood, glass, cane sugar, sulphur, common salt, pencil, rubber band, sponge, etc.

  Solid is defined as that form of matter which possesses rigidity, is incompressible and has a definite shape and a definite volume.
- **Liquid state:** In the liquid state, the particles are bound to each other with forces weaker than those in solids, and are loosely packed. This makes liquids mobile and shapeless. Liquids have tendency to flow but their fluidity is lower than that of gases due to the stronger interparticle attractive forces. A liquid possesses definite volume but no definite shape, i.e. a liquid takes the shape of the container in which it is kept. Liquid is relatively more compressible. Some common examples of liquids are water, oil, milk, alcohol, petrol, diesel, benzene, propanone, etc.

  Liquid is defined as that form of matter which possesses fluidity but is relatively more compressible and has a definite volume but no definite shape.
- **Gaseous state:** In the gaseous state, there is virtually no interparticle attractive force between the particles which are separated from each other by much greater distances, almost ten to hundred times their size. The particles in the gases are very loosely packed and they can move around freely.

The gaseous particles travel in straight lines in any direction until they collide with one another or with the container. This makes the gases shapeless and compressible. A gas has neither definite volume nor definite shape. A gas occupies the whole of the volume of the container in which it is kept. Due to large interparticle spaces and weak interparticle forces of attraction, gases have high fluidity and least rigidity. Some common examples of gases are hydrogen, nitrogen, oxygen, air, carbon dioxide, sulphur dioxide, nitrogen dioxide, etc.

Gas is defined as that form of matter which possesses fluidity but is highly compressible and has neither definite shape nor definite volume.

Activity 11

Demonstrating that liquids have a definite volume but no definite shape.

Take the following materials:

1. Four containers of different shapes
2. Water, kerosene oil, milk, soft drink

Put a 100 mL mark on the above containers using a measuring cylinder and water. Measure 100 mL of kerosene oil and transfer it into the above containers one by one. Repeat the step using milk and soft drink.

Spill the above four liquids one by one on the floor. Record your observations:

1. What happens to the shape of the liquids when these liquids are spilt on the floor?
2. Does the shape of the liquids remain the same in the above containers?
3. When one liquid is poured from one container into another, does the liquid flow easily?

Activity 11 indicates that the liquids have no fixed shape but have a fixed volume. The liquids take up the shape of the container in which the liquids are kept. The liquids flow easily and change shape, and hence they are not rigid and the liquids can be considered as fluid.

A comparison of the properties of solids, liquids and gases is given in Table 1.1.

Table 1.1 Comparison of the properties of solids, liquids and gases

Property	Solid	Liquid	Gas
1. Shape	Solids have definite shape due to the presence of strong interparticle attractive forces.	Liquids do not have definite shape because of weaker interparticle attractive forces.	Gases do not have definite shape due to the absence of any significant interparticle attractive forces.
2. Volume	Solids have definite volume.	Liquids have definite volume.	Gases do not have definite volume.
3. Compressibility and hardness	Due to close-packed structure, solids are hard and rigid and have very very low compressibility.	Liquids have low compressibility. Due to the presence of empty space in liquids, they are more compressible than solids.	Gases have high compressibility due to the presence of interparticle empty space.
4. Density (mass per unit volume)	Solids possess high density.	Liquids are less dense than solids.	Gases possess very low density as compared to liquids and solids.
5. Arrangement of particles	In solids, the atoms or molecules are very closely packed.	In liquids, the atoms or molecules are packed slightly loosely.	In gases, there is no order of arrangement of molecules. The particles are free to move in any direction.
6. Diffusion (free mixing of molecules)	Due to the immobility of particles in solids, the particles do not diffuse into one another.	Liquids exhibit slow diffusion.	Gases undergo diffusion freely.

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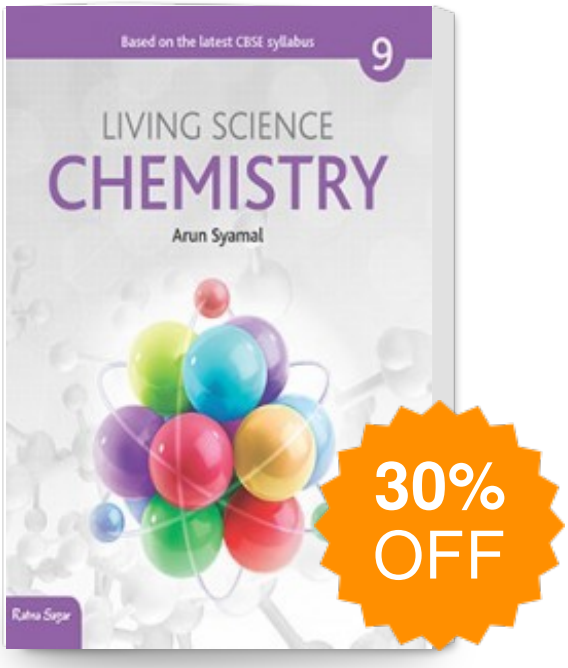

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