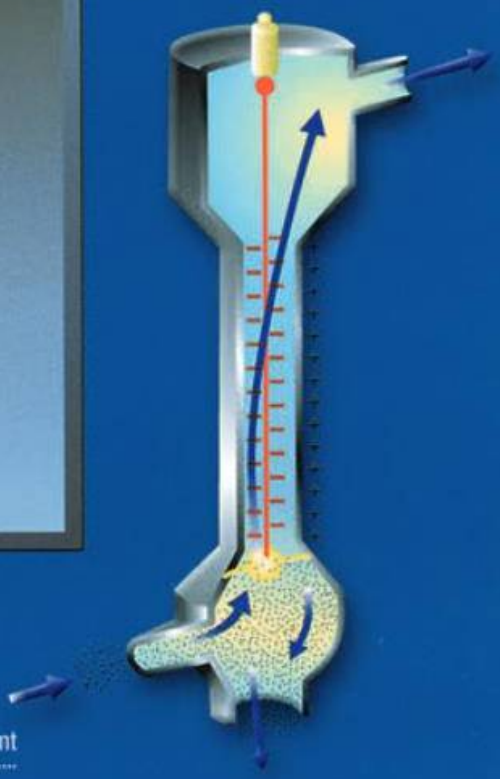
Basic Education - Grade Eight

Chemistry



National Textbook
New Curricula
Center for Educational Research and Development

Republic of Lebanon

Ministry of Education and Higher Education

CHEMISTRY

Basic Education

Grade Eight

Center for Educational Research and Development

National Textbook

New Curricula

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Together We Build Through Education!

The Center for Educational Research and Development (CERD) has embarked on an extensive workshop for assessing and developing the educational framework and curricula which have been placed into effect more than three years ago. With full realization of the fact that the educational cycle must continue normally through its components, and until the development process attains its aspired objectives, we are placing in the hands of students, teachers and directors of public schools, this corrected version of textbooks issued by CERD as part of the National Textbook Series.

This version is an interim stage incorporating the corrected typographical and linguistic errors discovered by CERD specialists as well as teachers and students through their daily dealings with the books. The process of assessment and development of the framework and curricula will take into consideration all the comments that have been made, or will be made, in this regard.

It is expected that once the curricula are developed and aligned with the general and specific objectives set for them, the textbooks will be realigned with the new curricular and framework requirements, including tying the content of a course to the number of teaching hours set for it during the school year, taking into consideration vertical alignment within the same course as well as the horizontal alignment with the rest of the courses.

I take this opportunity to invite all school administrators, teachers and students and all officials concerned in public and private schools alike, to promptly send their comments on these curricula and books as their contribution to enrichment of this momentous national process.

This workshop, which was launched under the kind sponsorship of His Excellency the Minister of Education and Higher Education in implementation of Decree No. 10227 embodying the educational curricula and their objectives, fits in with CERD's proclaimed new motto "Together We Build Through Education".

It is our earnest desire to see this national, all-inclusive workshop attracting the greatest amount of interest and participation to define the safest and soundest educational options that directly affect our children, as we vow to continually modernize education and develop its ways and means to keep abreast of modern developments and progress in science and technology.

Dr. Leila MALEEHA
President CERD

Introduction

In conformity with the objectives of the new curricula, this eigth grade chemistry book aims, through its content and methodology of teaching, to develop students into active learners.

- The teaching of notions and concepts is achieved through a set of activities which help develop the students' ability to actively participate in the laboratory work and class discussions, as well as encourage them to communicate through reading, writing and listening.

- The simplicity of the language and the use of a variety of educational materials (resources, tips on where to find information and how to use transparencies, videos, films, molecular models …), in each lesson provide novelty and nourish intellectual growth.

- To enhance the effectiveness of the text material and improve clarity and understanding, a large number of full-colored figures are used.

Features of this book

This book is divided into four units. The first unit includes two chapters, while the three other units include three chapters each.
Each unit starts with an overview of the subject matter to be covered.

Activities develop manipulative skills, use inexpensive materials and include clear and explicit directions that are easy to follow. These activities are the starting point for developing concepts and generalizations that are related to everyday – life experiences.

Chapter Review provides the key concepts and main ideas of the chapter.

Insights motivate students by showing them just how important and interesting chemistry really is.

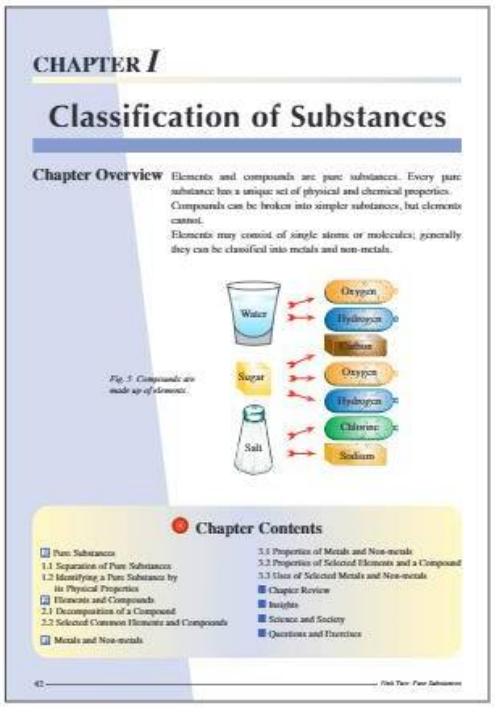
Science and Society includes real-life applications, help students relate the chemistry concepts to their everyday-life.

Questions and Exercises at the end of each chapter allow for a gradual and in–depth development of knowledge and skills to be attained. The questions and exercises are grouped into categories in terms of the cognitive level and types of skills they require.

All comments and suggestions are welcome.

The Authors

The eleven chapters of this book are all organized in the same format. In each chapter, distinguishing symbols are assigned to the different parts: Activity (materials, procedure, analysis and conclusion), Glossary, Remark, Safety, Chapter Review, Insights, Science and Society, Questions and Exercises.


CHAPTER *I*

Classification of Substances

Chapter Overview Elements and compounds are pure substances. Every pure substance has a unique set of physical and chemical properties. Compounds can be broken into simpler substances, but elements cannot.
Elements may consist of single atoms or molecules; generally they can be classified into metals and non-metals.

Water — Oxygen, Hydrogen
Sugar — Oxygen, Hydrogen, Carbon
Salt — Chlorine, Sodium

Fig. 5 Compounds are made up of elements.

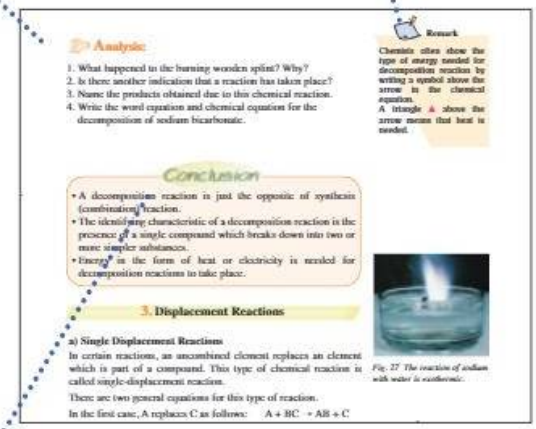
Chapter Contents

- Pure Substances
- 1.1 Separation of Pure Substances
- 1.2 Identifying a Pure Substance by its Physical Properties
- Elements and Compounds
- 2.1 Decomposition of a Compound
- 2.2 Selected Common Elements and Compounds
- Metals and Non-metals
- 3.1 Properties of Metals and Non-metals
- 3.2 Properties of Selected Elements and a Compound
- 3.3 Uses of Selected Metals and Non-metals
- Chapter Review
- Insights
- Science and Society
- Questions and Exercises

42 Unit Two Pure Substances

- Information correlated with the activity or text material.

- Questions leading to the attainment of the objectives.


Analysis:

1. What happened to the burning wooden splint? Why?
2. Is there another indication that a reaction has taken place?
3. Name the products obtained due to this chemical reaction.
4. Write the word equation and chemical equation for the decomposition of sodium bicarbonate.

Remark

Chemists often show the type of energy needed for decomposition reaction by writing a symbol above the arrow in the chemical equation.
A triangle Δ above the arrow means that heat is needed.

Conclusion

- A decomposition reaction is just the opposite of synthesis (combination) reaction.
- The identifying characteristic of a decomposition reaction is the presence of a single compound which breaks down into two or more simpler substances.
- Energy in the form of heat or electricity is needed for decomposition reactions to take place.

3. Displacement Reactions

a) Single Displacement Reactions

In certain reactions, an uncombined element replaces an element which is part of a compound. This type of chemical reaction is called single-displacement reaction.

There are two general equations for this type of reaction.

In the first case, A replaces C as follows: $A + BC \rightarrow AB + C$

Fig. 27 The reaction of sodium with water is exothermic.

Conclusion

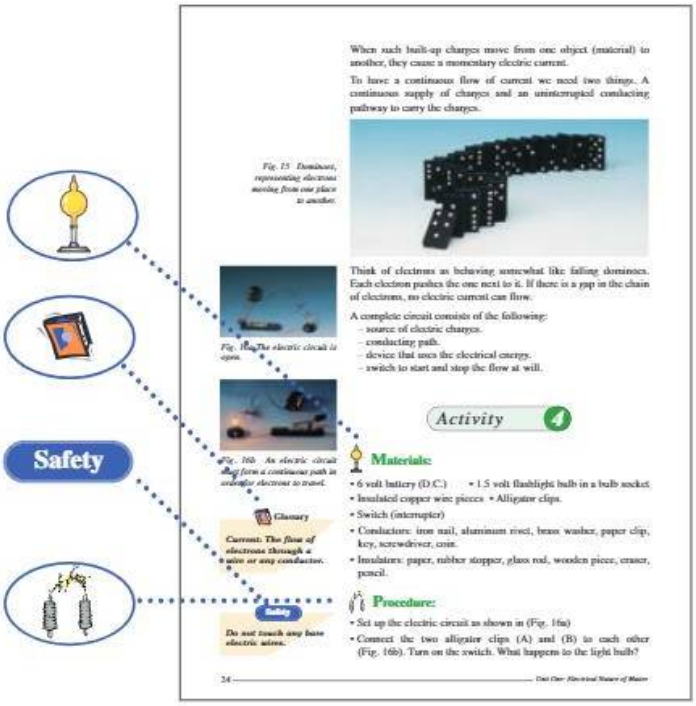
- Provides the concepts and factual knowledge to be mastered for that section.

- List of chemicals and equipment needed to perform the activity.

- A quick reference for definitions of terms used in the chapter.

- Safety instructions are given to prevent accidents. Safety is of prime importance in every classroom.

- Describing the different steps of the procedure.


When such built-up charges move from one object (material) to another, they cause a momentary electric current.

To have a continuous flow of current we need two things. A continuous supply of charges and an uninterrupted conducting pathway to carry the charges.

Fig. 15 Dominoes, representing electrons moving from one place to another.

Think of electrons as behaving somewhat like falling dominoes. Each electron pushes the one next to it. If there is a gap in the chain of electrons, no electric current can flow.

A complete circuit consists of the following:
– source of electric charges.
– conducting path.
– device that uses the electrical energy.
– switch to start and stop the flow at will.

Fig. 16a The electric circuit is open.

Fig. 16b An electric circuit must form a continuous path in order for electrons to travel.

Activity 4

Materials:

- 6 volt battery (D.C.) • 1.5 volt flashlight bulb in a bulb socket
- Insulated copper wire pieces • Alligator clips
- Switch (interrupter)
- Conductors: iron nail, aluminum rivet, brass washer, paper clip, key, screwdriver, coin.
- Insulators: paper, rubber stopper, glass rod, wooden piece, eraser, pencil.

Glossary

Current: The flow of electrons through a wire or any conductor.

Safety

Do not touch any bare electric wires.

Procedure:

- Set up the electric circuit as shown in (Fig. 16a)
- Connect the two alligator clips (A) and (B) to each other (Fig. 16b). Turn on the switch. What happens to the light bulb?

24 Unit One Electrical Nature of Matter

Science and Society

1. The Halogen Lamps

Halogen lamps contain metal halides – chemical compounds of a metal and a halogen. These compounds produce a more natural color than other lamps. Halogen lamps also last longer and produce more light for the same amount of electrical input. For these reasons, halogen lamps are excellent light sources for outdoor use.

They are also commonly used in car headlights.

Fig. 38 Halogen lamp.

2. Recycling of Aluminum

Aluminum cans are used in the beverage industry. The reasons for aluminum popularity is that it is non-toxic, odorless, tasteless, light in mass, and the liquid inside the container can be chilled rapidly.

The metal cans, when discarded, litter the countryside of our throw-away society. The best solution to this environmental problem and the way to prevent the rapid depletion of a finite source is recycling.

Fig. 39 Recycling of aluminum.

Chapter 2 - Classification of Substances 59

- Connecting the applications of chemistry to industry life.

Activity 3

Using ball-and-stick models or space-filling models construct models of some familiar molecular compounds.

Fig. 49 Ball-and-stick molecular models box.

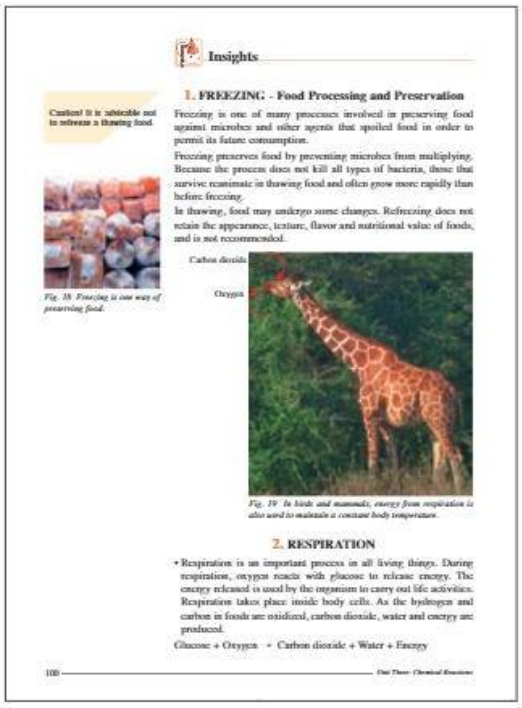
Chapter Review

- The particles of matter can be made up of individual atoms, molecules or ions.
- The atom consists of a small massive region called the nucleus and a large region surrounding the nucleus called the electron cloud.
- The three fundamental particles of the atom are protons, neutrons and electrons.
- An atom is mainly made up of empty space.
- The atom is the smallest entity of an element and is made up of neutrons, and an equal number of electrons and protons.
- The number of protons in the nucleus of an atom is called atomic number and is denoted by the letter Z.
- A molecule is a neutral group of combined atoms that act as a unit.
- The ion, is an atom or group of combined atoms carrying a positive or negative charge.
- Positive ions are called cations and negative ions are called anions.

Concept Mapping

Chapter 3 - Structure of Matter 71

- Provides the the fundamental points and key concepts by schematic synthesis.



Insights

Caution! It is advisable not to refreeze a thawing food.

1. FREEZING - Food Processing and Preservation

Freezing is one of many processes involved in preserving food against microbes and other agents that spoiled food in order to permit its future consumption.

Freezing preserves food by preventing microbes from multiplying. Because the process does not kill all types of bacteria, those that survive reanimate in thawing food and often grow more rapidly than before freezing.

In thawing, food may undergo some changes. Refreezing does not retain the appearance, texture, flavor and nutritional value of foods, and is not recommended.

Fig. 38 Freezing is one way of preserving food.

Carbon dioxide

Oxygen

Fig. 39 In birds and mammals, energy from respiration is also used to maintain a constant body temperature.

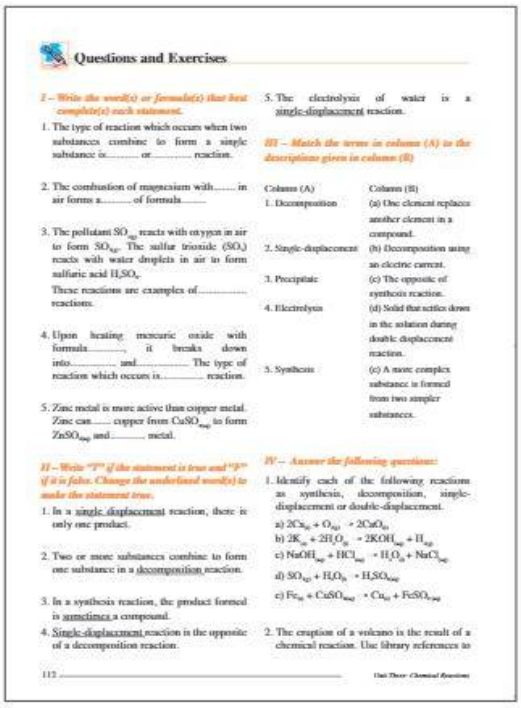
2. RESPIRATION

- Respiration is an important process in all living things. During respiration, oxygen reacts with glucose to release energy. The energy released is used by the organism to carry out life activities. Respiration takes place inside body cells. As the hydrogen and carbon in foods are oxidized, carbon dioxide, water and energy are produced.

Glucose + Oxygen → Carbon dioxide + Water + Energy

100 Unit Three: Chemical Reactions

- Special science rubrics to show the role and importance of chemistry in everyday-life.



Questions and Exercises

I – Write the word(s) or formula(s) that best complete(s) each statement.

1. The type of reaction which occurs when two substances combine to form a single substance is..... or..... reaction.

2. The combustion of magnesium with..... in air forms a..... of formula.....

3. The pollutant $SO_{(g)}$ reacts with oxygen in air to form $SO_{3(g)}$. The sulfur trioxide (SO_3) reacts with water droplets in air to form sulfuric acid H_2SO_4.
These reactions are examples of..... reactions.

4. Upon heating mercuric oxide with formula....., it breaks down into..... and..... The type of reaction which occurs is..... reaction.

5. Zinc metal is more active than copper metal. Zinc can..... copper from $CuSO_{4(aq)}$ to form $ZnSO_{4(aq)}$ and..... metal.

II – Write "T" if the statement is true and "F" if it is false. Change the underlined word(s) to make the statement true.

1. In a single displacement reaction, there is only one product.

2. Two or more substances combine to form one substance in a decomposition reaction.

3. In a synthesis reaction, the product formed is sometimes a compound.

4. Single-displacement reaction is the opposite of a decomposition reaction.

5. The electrolysis of water is a single-displacement reaction.

III – Match the terms in column (A) to the descriptions given in column (B)

Column (A)	Column (B)
1. Decomposition	(a) One element replaces another element in a compound.
2. Single-displacement	(b) Decomposition using an electric current.
3. Precipitate	(c) The opposite of synthesis reaction.
4. Electrolysis	(d) Solid that settles down in the solution during double displacement reaction.
5. Synthesis	(e) A more complex substance is formed from two simpler substances.

IV – Answer the following questions:

1. Identify each of the following reactions as synthesis, decomposition, single-displacement or double-displacement.
a) $2Ca_{(s)} + O_{2(g)} \rightarrow 2CaO_{(s)}$
b) $2K_{(s)} + 2H_2O_{(l)} \rightarrow 2KOH_{(aq)} + H_{2(g)}$
c) $NaOH_{(aq)} + HCl_{(aq)} \rightarrow H_2O_{(l)} + NaCl_{(aq)}$
d) $SO_{3(g)} + H_2O_{(l)} \rightarrow H_2SO_{4(aq)}$
e) $Fe_{(s)} + CuSO_{4(aq)} \rightarrow Cu_{(s)} + FeSO_{4(aq)}$

2. The eruption of a volcano is the result of a chemical reaction. Use library references to

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- Testing knowledge and evaluating the development of skills.

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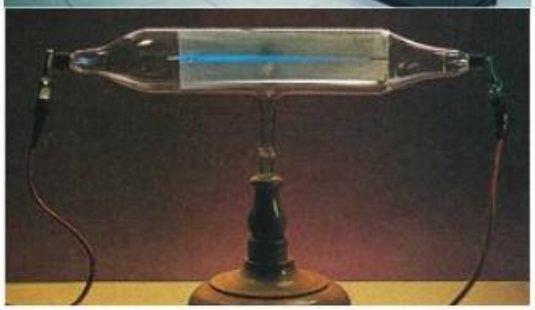
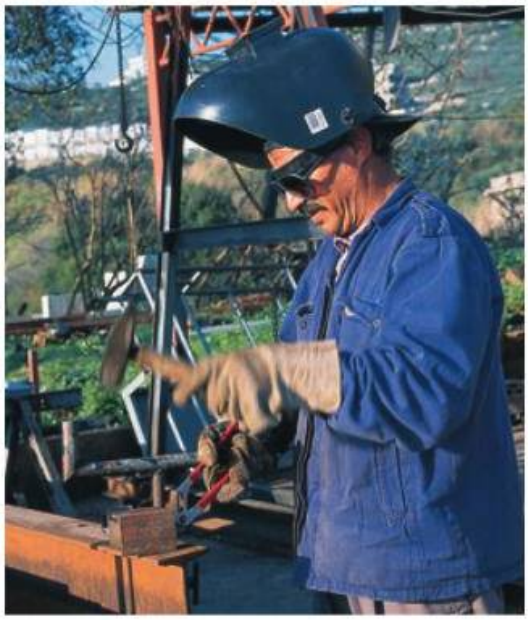
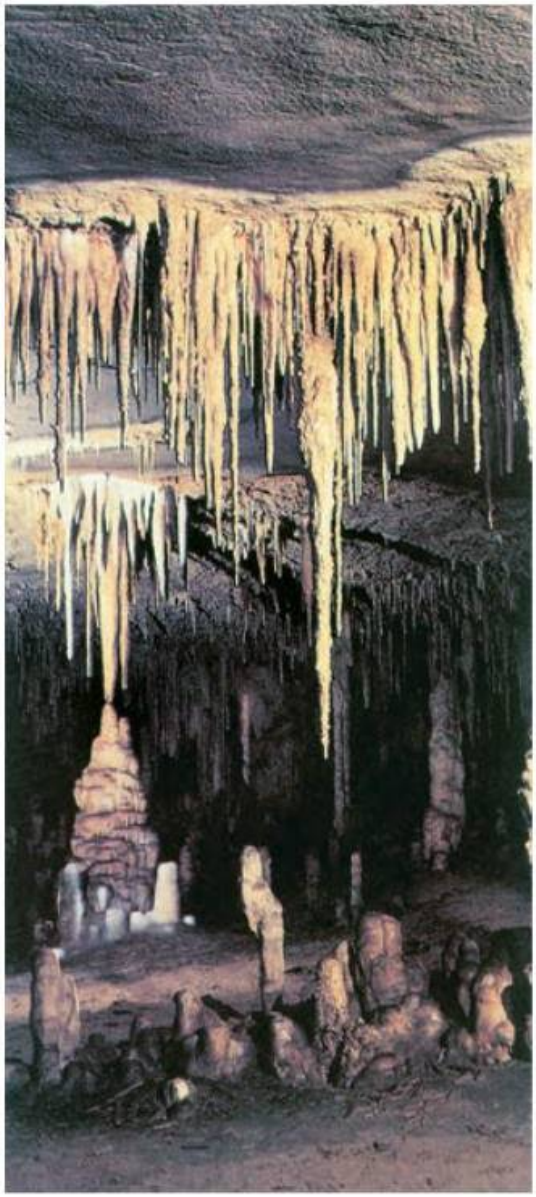


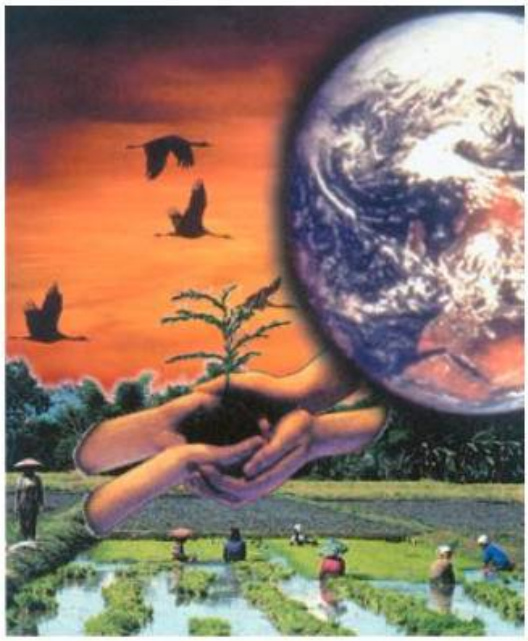
Unit Two: Pure Substances



Unit Three: Chemical Reactions



Unit Four: Acids, Bases and Salts



Unit One

Electrical Nature of Matter

Fig. 1 Lightning. We see electric effects when sparks are generated.

Unit Overview

When you think of electricity, you probably think of something that comes from a wall outlet, «flows» and operates a machine or appliance. Yet, there is another kind of electricity that «does not flow» but involves a build-up of charges. It is called static electricity.

This latter kind of electricity explains the electrical nature of matter and is useful for classifying substances in terms of their ability to conduct electrical charges.

Contents

Fig. 2 A stream of charged particles flows in a cathode ray tube. The picture tube in a television is a complex version of cathode tube.

Fig. 3 Charges of subatomic particles hold the structure of matter on the atomic level and therefore control the structure of matter in the macroscopic world.

Fig. 4 Charges on the move.

CHAPTER *I*

Electric Charge

Chapter Overview

The nature of an electric charge in matter is related to subatomic particles.

Materials can be classified into conductors and insulators depending on their ability to conduct electricity.

The phenomenon of charging materials is called electrification.

Fig. 5 The effects of static electricity can be demonstrated by this simple activity.

Chapter Contents

1 Electrification

1.1. Electrical Properties

You may have noticed that sparks accompany a crackling sound when you take off a nylon shirt at the end of a dry winter day.

Activity 1

Materials:

• Ebonite rod • Wool cloth • Silk cloth • Glass rod • Paper

Fig. 6a Pieces of paper and an uncharged ebonite rod.

Fig. 6b Charging ebonite rod by friction.

Glossary

***Ebonite:** A hard black rubber used as an insulating agent.*

Procedure:

- Cut the paper into tiny pieces.
- Hold the ebonite rod close to the bits of paper (Fig. 6a). Observe what happens.
- Rub the ebonite rod with the wool cloth (Fig. 6b) and hold it close to the bits of paper (Fig. 6c). Observe what happens.
- Keep holding the ebonite rod for a few minutes. Observe what happens to the bits of paper.
- Repeat the above procedure using a glass rod and a silk cloth.

Fig. 6c Charged ebonite rod attracting pieces of paper.

Remark

- ***Not all materials can be charged by rubbing.***
- ***Materials that can be charged by rubbing should be dry.***

Fig. 6d Charging glass rod by friction.

Fig. 6e Charged glass rod attracting pieces of paper.

Analysis:

1 - What happens to the bits of paper when you hold close:
  – the ebonite rod before and after rubbing with the wool cloth?
  – the glass rod before and after rubbing with the silk cloth?
2 - What caused the bits of paper to be attracted by the ebonite rod, And by the glass rod?
3 - Would the property of the rubbed material disappear after you wait for a while?

Fig. 7 Benjamin Franklin, (1706-1790), American physicist, arbitrarily proposed that the charge obtained on a glass rod when rubbed with silk is positive; that on a rubber rod rubbed with wool or fur is negative.

Conclusion

- Some materials become electrically charged by rubbing (friction).
- Charging of materials by rubbing develops a static electric charge on the surface of the rubbed materials.
- Electrical force of interaction develops due to rubbing.
- The phenomenon of charging a material is called electrification.

1.2. Two Kinds of Electric Charges

There are just two kinds of electric charges, positive and negative. How do charged objects interact with each other?

Remark

An object that has neither a positive nor a negative charge is considered neutral.

Activity 2a

Materials:

- Glass rod
- Ebonite rod
- Aluminum ball
- Wool cloth or fur
- Thread
- Silk cloth
- (2) Stands (insulated)

Procedure:

- Suspend an aluminum ball from a stand.
- Rub the glass rod with the silk cloth, then bring it near the suspended aluminum ball without touching.
- Now, move the glass rod until it is in touch with the suspended ball, then wait for about 30 seconds.
- Rub the ebonite rod with wool cloth (or fur) and bring it near the above charged aluminum ball without touching (Fig. 8).

Fig. 8 Aluminum ball attracted to a charged ebonite rod.

Analysis:

1. What caused the suspended ball to be attracted by the glass rod?
2. Why was the ball suddenly repelled by the glass rod?
3. What happened when the charged ebonite rod was brought near the suspended charged ball?

Activity 2b

- Suspend an ebonite rod (A) from a stand, then rub it at one of its ends with a wool cloth.
- Rub another ebonite rod (B), at one of its ends, using the same wool cloth.
- Hold the ebonite rod (A) and (B) near each other (Fig. 9a). Observe what happens.
- Suspend a glass rod (C) from a stand then rub it with a silk cloth at one of its ends. Hold the ebonite rod (B) near the glass rod (C) (Fig. 9b). Observe what happens.

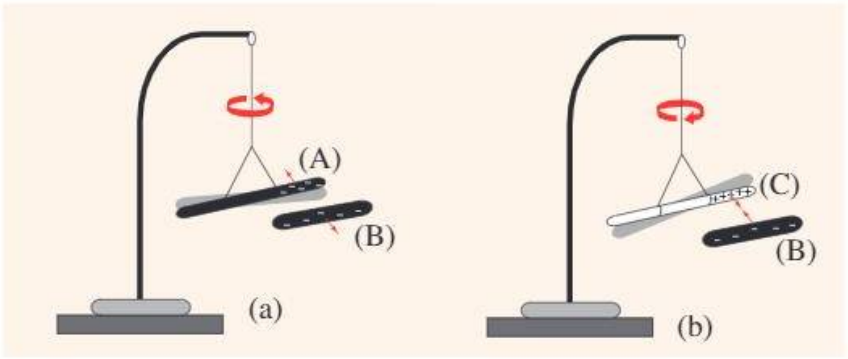


Fig. 9 Electric charges exert force on other charges over a distance.

Remark

The suspended glass and ebonite rods should be thin.

Analysis:

1. Is repulsion or attraction observed when:
   – rod (B) is placed near rod (A)?
   – rod (B) is placed near rod (C)?
2. What kind of force caused the repulsion or the attraction?
3. Is the electric charge developed by friction
   – on the two ebonite rods, the same or different?
   – on the glass rod and the ebonite rod, the same or different?

Conclusion

- There are two kinds of electric charges, conventionally denoted by (+) positive and (-) negative.
- Electric charges exert force on other charges over a distance.
- Objects carrying like charges repel each other.
- Objects carrying unlike charges attract each other.

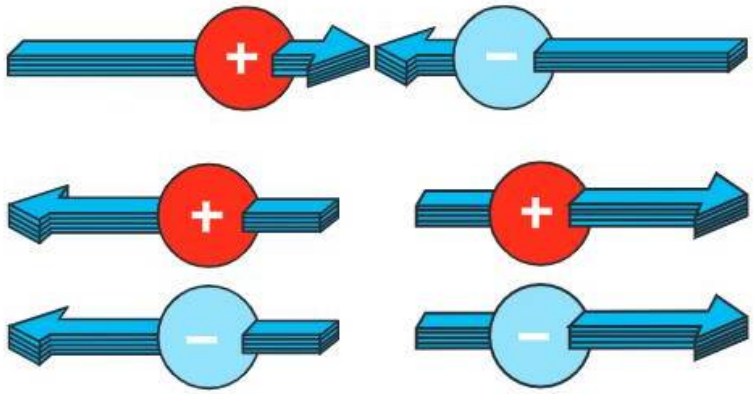


Fig. 10 Behavior of electric charges.

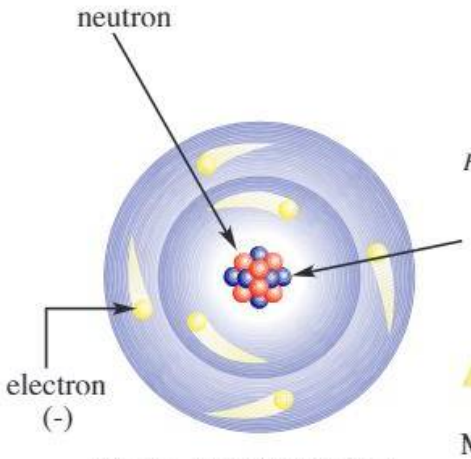


Fig. 11 A model of an atom, showing the three main subatomic particles of the atom.

1.3. Electric Charges in Atoms

Matter is made up of tiny particles called atoms. The atoms contain subatomic particles. Two of these subatomic particles, the proton and the electron, have an electric charge. A third subatomic particle, the neutron, has no electric charge.

The protons and neutrons are found in the central part of the atom, called the nucleus. They remain fixed in their positions. The electrons surround the nucleus and are in motion.

The movement of electrons makes the electricity we use daily.

The electrification of neutral objects, when rubbed against each other, is explained by the fact that some of the electrons move or «transfer» between the rubbed objects. When an ebonite rod is rubbed against a wool cloth, the atoms of the rubbed wool lose some of their electrons to the ebonite rod. The rod becomes negatively charged and the wool becomes positively charged (Fig. 12a). When a glass rod is rubbed with a silk cloth the atoms of the glass lose some of their electrons to the silk. The silk becomes negatively charged and the glass rod becomes positively charged (Fig. 12b). However, the total charge of the two objects remains the same, that is the charge is conserved.

- ***An atom has the same number of protons and electrons.***
- ***The negative charge of an electron neutralizes the positive charge of a proton.***
- ***Charges are not created but separated.***
- ***A negatively charged object has an excess of electrons.***

Static electricity

The build up of electric charges on the surfaces of rubbed objects is called static electricity.

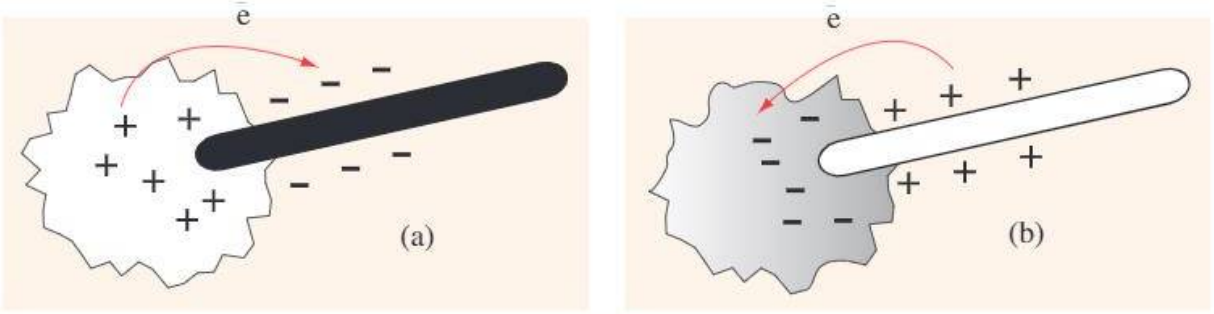


Fig. 12 Electrons are transferred between materials by friction (Rubbing).

2 Conductors and Insulators

2.1. Classifying Materials into Conductors and Insulators

It is convenient to classify materials in terms of their ability to conduct an electric charge.

You have probably seen tall metallic or wooden towers support wires that carry electricity. Also, you may have seen wires leading from public service power lines to houses pass through porcelain or ceramic insulators.

Fig. 13 Pylon for electric power lines.

Activity 3

Materials:

- Metal rods (brass, copper)
- Silk cloth
- Stand (insulated)
- Glass rod
- Aluminum ball with a holder
- Ebonite rod
- Wool cloth or fur.
- Plastic support

Procedure:

- Place a copper rod on a plastic support in contact with the aluminum ball, initially neutral, (Fig. 14a).
- Rub an ebonite rod with fur or wool cloth at one end and place the rubbed end in contact with the copper rod (Fig. 14b).
- Remove the copper rod and its support, then hold the ebonite rod close to the suspended ball (Fig. 14c).
- Repeat the above procedure, using a glass rod instead of the metal (copper) rod (Fig. 14d).

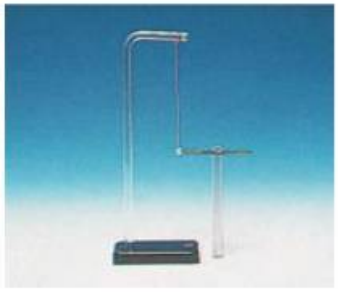


Fig. 14a

Fig. 14b

Fig. 14c

Fig. 14d

Analysis:

1. What happens when the copper rod held by the plastic support is placed in contact with the suspended aluminum ball?
2. What happens when the rubbed end of the ebonite rod is placed in contact with the copper rod?
3. What happens when the copper rod is removed and the ebonite rod is brought near to the suspended ball?
4. What do you observe when the copper rod is replaced by the glass rod and the rubbed ebonite rod is put in contact with the glass rod?

Conclusion

- A conductor is a material that allows electrons to move easily through it.
- An insulator is a material that does not allow electrons to move through it easily.

Table 2.1 Some common conductors and insulators

Conductors	Insulators
• Metals: copper, silver, iron, aluminum, gold	• Plastic, rubber
• Alloys: steel, bronze, brass	• Glass, porcelain
• Human body	• Ceramic
• Graphite, a form of carbon	• Wood (dry)
	• Air
	• Diamond, another form of carbon

In general, metals are good conductors, whereas non-metals are insulators.

Some materials, however, have properties that are intermediate between those of a good conductor and a good insulator. These materials are semiconductors; example silicon.

2.2. Charges on the Move

The build-up of electric charges on a surface is called static electricity. Electrical charges are collected and held in one place.

When such built-up charges move from one object (material) to another, they cause a momentary electric current.

To have a continuous flow of current we need two things. A continuous supply of charges and an uninterrupted conducting pathway to carry the charges.

Fig. 15 Dominoes, representing electrons moving from one place to another.

Think of electrons as behaving somewhat like falling dominoes. Each electron pushes the one next to it. If there is a gap in the chain of electrons, no electric current can flow.

A complete circuit consists of the following:
- source of electric charges.
- conducting path.
- device that uses the electrical energy.
- switch to start and stop the flow at will.

Fig. 16a The electric circuit is open.

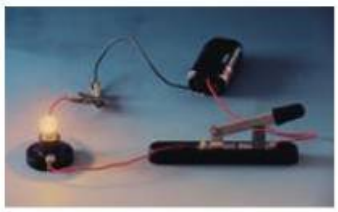


Fig. 16b An electric circuit must form a continuous path in order for electrons to travel.

Activity 4

Materials:

- 6 volt battery (D.C.)
- 1.5 volt flashlight bulb in a bulb socket
- Insulated copper wire pieces
- Alligator clips.
- Switch (interrupter)
- Conductors: iron nail, aluminum rivet, brass washer, paper clip, key, screwdriver, coin.
- Insulators: paper, rubber stopper, glass rod, wooden piece, eraser, pencil.

Procedure:

- Set up the electric circuit as shown in (Fig. 16a)
- Connect the two alligator clips (A) and (B) to each other (Fig. 16b). Turn on the switch. What happens to the light bulb?

Glossary

Current: The flow of electrons through a wire or any conductor.

Safety

Do not touch any bare electric wires.

- Put the switch on «off» position and disconnect the alligator clips.
- Connect the alligator clips to the coin and put the switch «on». What happens to the light bulb?
- Repeat the trial with other available objects and observe what happens to the light bulb in each case.

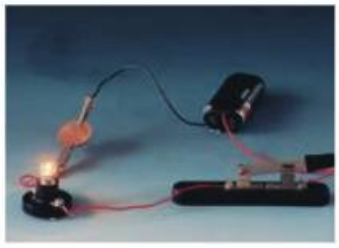


Fig. 17a Coin is a conductor.

Analysis:

- Classify the objects into conductors and insulators. (Complete the following table in your copybook).

Conductors (bulb lights up)	**Insulators** (bulb does not light up)
Coin	Wood

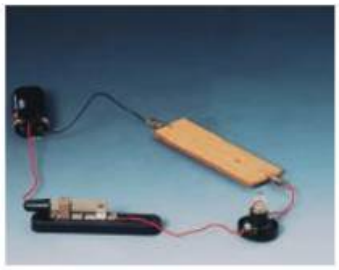


Fig. 17b Wood is a non-conductor (insulator).

The electric cords shown below carry electricity in copper wires. The insulator stops charges from flowing from the wire to your hand.

Fig. 18 Electric cords inside an insulator plastic material.

Conclusion

- Substances vary in their ability to conduct electricity.
- Metals such as aluminum, copper, iron and metallic alloys such as brass, and steel are good conductors of electricity.
- Non-metallic objects such as rubber, plastic, ceramics and glass are insulators (non-conductors).

Chapter Review

- Rubbing (friction) causes charges to develop on the surfaces of some objects.
- The phenomenon of charging objects is called electrification.
- There are two kinds of electrical charges. Positive electrical charges denoted by (+) and negative electrical charges denoted by (-).
- Electrical charges exert an electric force on other charges.
- Like charges repel each other, unlike charges attract each other.
- The three fundamental subatomic particles are: proton, neutron and electron.
- The nucleus is the central massive part of the atom. It contains the protons and the neutrons. The electrons rotate around the nucleus.
- The build-up of electrical charges on the surfaces of rubbed objects is called static electricity.
- Conductors are materials in which electric charges move freely.
- Insulators (non-conductors) are materials in which electric charges do not move freely.
- The continuous flow of electrons through wires or conductors makes «electricity» or «electric current».

Insights

The effect of electrical charges on conductors and non-conductors.

The three objects in (Fig. 19) demonstrate the way in which electrical charges affect conductors and non-conductors. A negatively charged rod (A) affects the way charges are distributed in a nearby conductor (B) and a non-conductor (C). A positive charge is induced on the sides of (B) and (C) that are nearest to (A); a negative charge is induced on the sides of (B) and (C) that are farthest from (A). In the conductor (B), the separation of charge

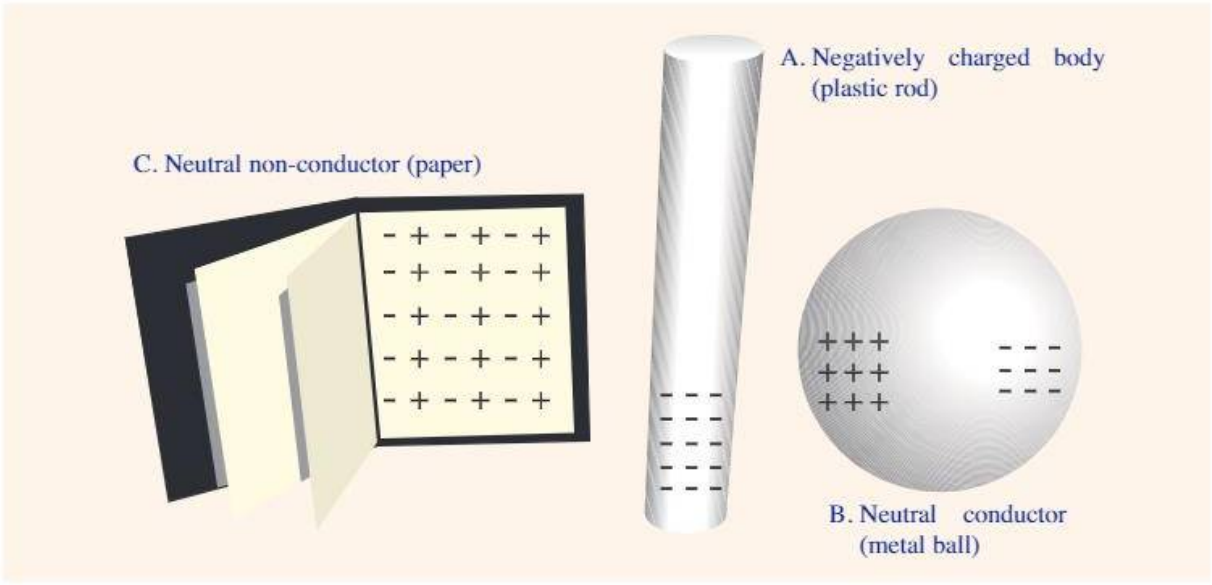


Fig. 19 Induced Electrical Charges.*

** Induced Electrical Charges," Microsoft(R) Encarta(R) 97 Encyclopedia. (c) 1993-1996 Microsoft Corporation. All rights reserved.*

involves the entire object because the electrons are free to move. In the non-conductor (C), the separation of charge is limited to the way in which the electrons redistribute themselves within an atom. This effect is most noticeable if the non-conductor is close to the charged object.

Science and Society

1. Fabric Softeners and Hair Conditioners

Clothes made of wool or silk tend to pick up electric charges due to friction, when they tumble in the dryer. Some fabrics lose electrons and become positively charged while others pick up electrons and become negatively charged. Some fabrics remain neutral and do not pick up an electrical charge. The electric force of attraction causes the clothes to stick together. The electrically charged fabric will cling to other objects as well.

Fig. 20 Clothes taken from a dryer often cling together because they are electrically charged.

If you run a comb through your hair, as you dry it with an electric dryer, friction may cause electrons to move from your hair and build up on the comb which becomes negatively charged. The positive charges on your hair repel each other and your hair won't stay flat. It flies everywhere.

Fabric softeners and hair conditioners were developed to deal with these problems. These products lubricate surfaces with a waxy or soapy substance. A thin coating of these products reduces the friction between the cloth or hair surfaces during the drying process. The reduced electron build-up controls the amount of static electricity.

Fig. 21 Hair conditioner and fabric softeners reduce electron build up.

2. Static Electric Precipitators and Air Pollution

Many sources of air pollution can be neutralized. Particles from combustion in power plants and waste incinerators, and dust from cement manufacturing and other industrial plants can be removed by using a simple air cleaning device: *the electrostatic precipitator.*

Electrostatic precipitators trap particles in smoke and ash before they escape to the atmosphere.

The ashes are given an electric charge. They are then trapped as they pass near plates with an opposite electric charge. The collected ash is disposed of in sanitary landfills.

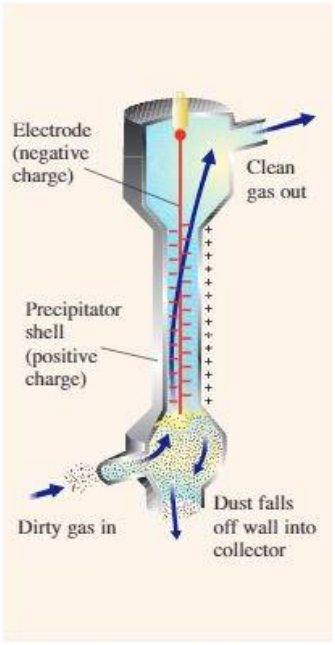


Fig. 22 99% of the particles can be removed using electrostatic precipitators.

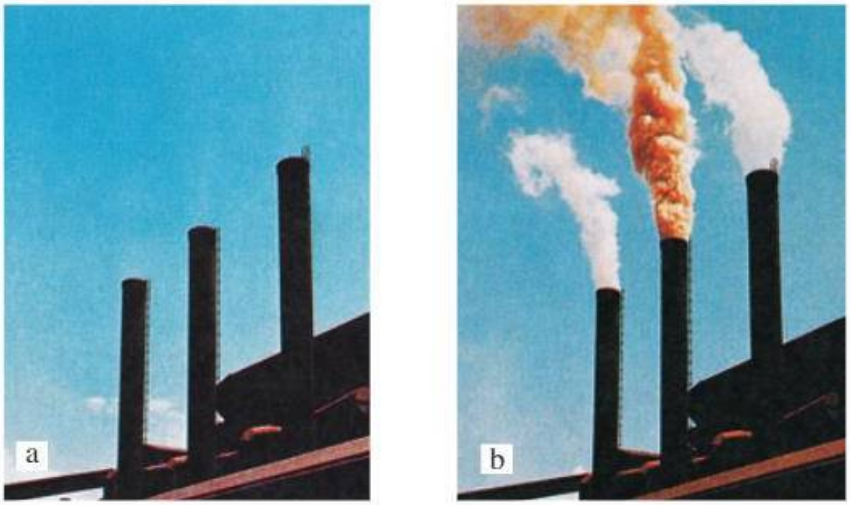


Fig. 23 Smoke coming from stacks like these affect the atmospheric air. In (a) the device is on, in (b) it is off.

Questions and Exercises

I- Write the word(s) that best complete(s) each statement.

1. When a glass rod is rubbed with silk, the glass rod acquires a..... charge, and the silk a..... charge.
2. Every atom contains an equal number of..... and.....
3. When a neutral body loses some of its electrons, it becomes..... charged.
4. Substances through which electrons flow freely are called....., while substances which do not permit the flow of electrons are called.....
5. A positively charged object possesses a(n)..... of electrons.
6. Charges move..... on a conductor, while on an insulator they..... on one place.
7. An object is charged by..... when no contact is made with the charging object.

II- Circle the letter of the answer that best completes each statement.

1. When a plastic ruler is rubbed with wool, it
   a) gains electrons
   b) loses electrons
   c) gains protons
   d) loses protons

2. A rod that repels a positively charged glass rod:
   a) must be positively charged
   b) must be negatively charged
   c) may be uncharged
   d) may be positively or negatively charged.

3. Of the following, the material through which electrons flow easily is:
   a) glass
   b) air
   c) copper
   d) wood

4. A material that is a good insulator is:
   a) silver
   b) iron
   c) diamond
   d) aluminum

5. When two materials are charged by friction between them:
   a) both lose electrons
   b) both gain electrons
   c) one loses electrons to the other
   d) there is no change in the number of electrons each has

6. When two balloons are rubbed by a piece of wool, you would expect the balloons to:
   a) attract each other
   b) repel each other
   c) charge each other
   d) have no effect on each other

7. When an insulated object is charged by induction because of a nearby charged object:
   a) both objects lose electrons
   b) both gain electrons
   c) one loses electrons to the other
   d) there is no change in the number of electrons each has

8. When two charged objects are moved farther apart, the force between them:

   a) increases

   b) increases only if both have the same kind of charge

   c) increases only if both have the opposite kind of charge

   d) decreases

III- Write «T» if the statement is true and «F» if it is false.

1. Two objects rubbed together acquire their charge by induction.

2. A negatively charged object has an excess of protons.

3. The electrons surround the nucleus of the atom, and move freely around it.

4. The atom is electrically neutral; it does not contain electric charges.

5. An ebonite rod rubbed by a piece of wool becomes negatively charged.

6. Two electrons will repel each other.

IV- Answer the following questions:

1. A, B, C, and D are electrically charged bodies.

   A repels B; B attracts C; C attracts D; D is positively charged.

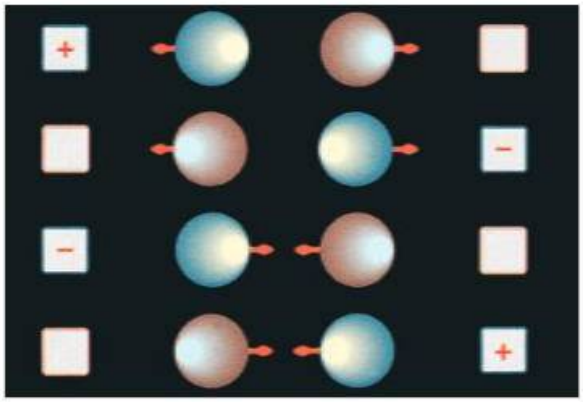
   What kind of electric charge is carried by C? B? A?

2. What is the difference between a conductor and an insulator?

3. Hold one extremity of a copper rod with your hand, and rub the other extremity by a piece of wool. When you bring the rubbed extremity of the copper rod near bits of paper or other very light objects, nothing is observed. That is, the copper rod is not charged. Why?

4. Design (outline) an experiment to show that water contains static electricity.

5. Put the information of the following schematic diagram into a table form.



6. Choose the best answer and rewrite the following sentences in your copy book.

   a) A metallic conductor: possesses/does not possess moving charges (Free electrons).

   b) An insulator: possesses/does not possess free electrons.

   c) A plastic ruler: deviates/does not deviate a thin flow stream of water.

CHAPTER *II*

Electric Discharge

Chapter Overview

The loss of static electricity as electric charges move off an object is called electric discharge. One of the most dramatic examples of the discharge of static electricity is lightning.

Electricity is one of the most useful energy resources. But electricity can be dangerous if it is not used safely.

Fig. 24 Lightning contains dangerously high amounts of electric energy.

Chapter Contents

1 The Electroscope

The electroscope is a device used to demonstrate charging by contact (conduction), to detect the presence of an electrical charge and to determine the sign of the charge.

Fig. 25a Electroscope Uncharged leaves hang down under the influence of gravity.

Essential Features of Electroscope

A typical electroscope consists of a metal rod with a knob at the top and a pair of thin metal leaves at the bottom. The metal rod is inserted through an insulating plug into a metal case with glass windows, (Fig 25a) or in a large Erlenmeyer flask (Fig 25b).

Fig. 25b An electroscope is a device which detects static electric charges.

1.1. Charging by Contact (Conduction)

Activity 1

Materials:

- Electroscope
- Ebonite rod
- Glass rod
- Wool cloth
- Silk cloth

Procedure:

- Rub the ebonite rod with a wool cloth and quickly hold the charged ebonite rod in contact with the knob on top of the metallic rod of the electroscope.
- Repeat the above procedure using a glass rod and a silk cloth.

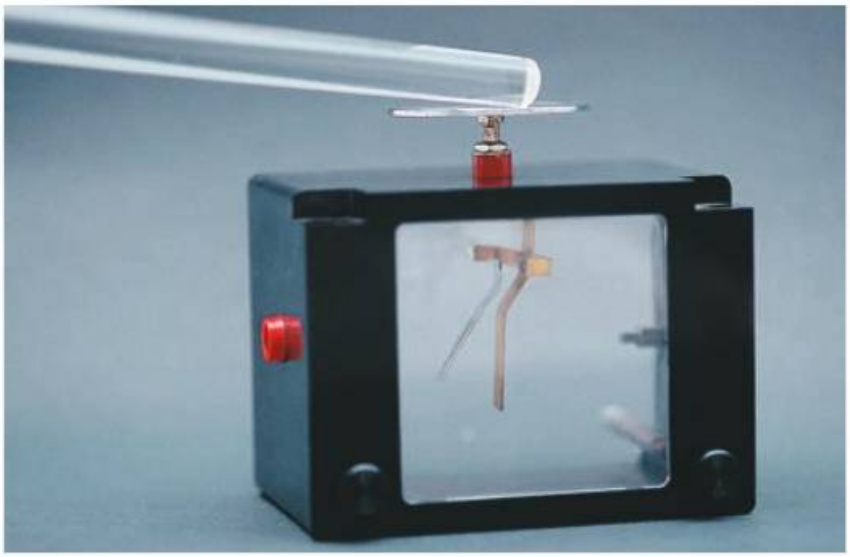


Fig. 25c Charging of electroscope by contact.

Analysis:

1. How do the thin metal leaves behave when the ebonite rod is put in contact with the knob?
2. What happens to the leaves when the ebonite rod is removed?
3. Does the glass rod show the same results as those obtained with the ebonite rod?

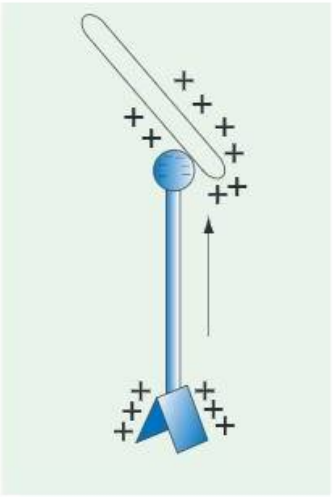


Fig. 26a Electrons move toward the knob.

Conclusion

- Charging by contact (conduction) involves the flow of electrons through one object to another object.
- An electroscope can be charged by contact (conduction).
- An electroscope charged by contact, takes on the same charge as the charging object.

Activity 2a

Materials:

- Electroscope
- Ebonite rod
- Wool cloth

Procedure:

- Charge the ebonite rod with the wool cloth.
- Charge the electroscope with the charged ebonite rod.
- Bring the wool cloth, used to charge the ebonite rod, into direct contact with the knob of the electroscope. Observe what happens.

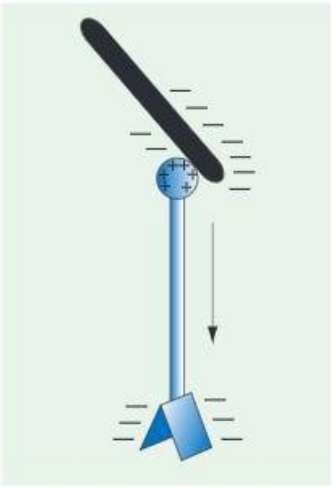


Fig. 26b Electrons move away from the knob.

Activity 2b

- Repeat the charging of the electroscope with the charged ebonite rod.
- Slowly bring a newly charged ebonite rod into contact with the charged electroscope. Observe what happens.

Glossary

Contact (Conduction): involves the flow of electrons through one material to another.

Analysis:

What can you say about the sign of:

1 - the initially charged electroscope?

2 - the charge of the wool cloth used?

3 - the newly charged ebonite rod?

Conclusion

A charged electroscope can identify whether an object is charged with the same charge or with an opposite charge.

Fig. 27a Charging by induction.

1.2. Charging by Induction

Activity 3

Fig. 27b Discharging of an electroscope.

Materials:

- Electroscope
- Glass rod
- Wool cloth
- Ebonite rod
- Silk cloth

Procedure:

Fig. 27c The electroscope is negatively charged.

- Rub a glass rod with the silk cloth and bring it near the knob (without being in contact with the neutral knob).
- Touch the knob with your finger while the glass rod is still near the electroscope.
- Move your finger away from the knob and then take away the glass rod.
- Repeat the preceding procedure using the ebonite rod and the wool cloth.

Analysis:

1. What happens to the metal leaves when the glass rod is brought near the knob, without touching?
2. What happens to the metal leaves after touching the knob with your finger?
3. What happens to the metal leaves when you first remove your finger from the knob, then take away the glass rod?
4. What kind of charge will develop on the knob when the glass rod is used? When the ebonite rod is used?

Remark

Induction:
Involves a rearrangement of electric charges.

Conclusion

- Charging an object by induction requires no contact with the object inducing the charge.
- A conductor (such as the metal knob) charged by induction would end up with an opposite charge to that of the inducing object.

2 Phenomenon of Electric Discharge

Scuffing your feet across a carpet during a dry day may give your body an overall static electric charge. When you touch the metal door knob, the charge flows between your hand and the door knob and you feel a weak shock. The accumulated charge on your body's surface completes its path through the metal knob to the earth and your body becomes neutral. This phenomenon is called electric discharge.

Fig. 28 The charge flows between your hand and the door knob and you feel a shock.

Activity 4

Materials:

- Ebonite rod
- Fur or (wool cloth)
- Glass rod
- Silk cloth
- Two aluminum balls (A) and (B) (each tied by a thread)

2 plastic stands (insulated)

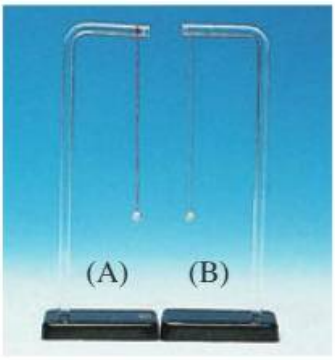


Fig. 29a Two neutral aluminum balls (A) and (B).

Fig. 29b Suspended aluminum ball attracted to charged ebonite rod.

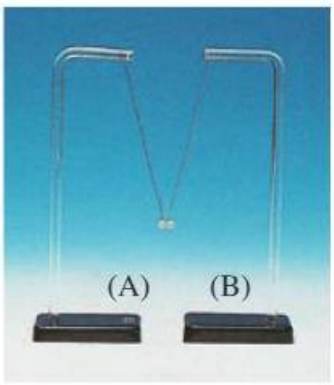


Fig. 30 Oppositely charged aluminum balls attract each other.

Procedure:

- Suspend the two aluminum balls (A) and (B), (Fig. 29a).
- Charge the ebonite rod with fur or (wool cloth) and the glass rod with the silk cloth.
- Place the ebonite rod in contact with ball (A) (Fig. 29b), and the glass rod with ball (B).
- Place the two stands close to each other (Fig. 30). Observe what happens.
- Hold each ball with your hand for a few seconds, then let go. Observe what happens.

Analysis:

1. What kind of charge develops on ball (A)? ball (B)?
2. What happens when the two balls are placed near each other?
3. What happens to the balls after you hold each with your hand?

Conclusion

- A positively or negatively charged object becomes neutral upon discharging.
- Grounding (earthing) ensures the electric discharge of an object.

Glossary

Grounding: **is electrically connecting an object to earth to eliminate excess charge.**

3 Electricity and Safety

Electricity is a useful source of energy, but it can be dangerous, too.

The human body is a conductor of electricity. Electric current flowing through the body can cause a shock that disturbs the nerves in the body and may cause death.

When too much current flows through a wire, the wire may overheat or emit sparks.

The heat and sparks could result in a fire.

Electrical safety rules:

- Never touch an electric appliance when your hands are wet.
- Do not use electric appliances near water.
- Do not connect several electric extension cords together.
- Do not plug too many appliances into one outlet.
- Do not allow electric cords to become worn.
- Do not run electric cords under carpets.
- Never touch an electric wire that has fallen from electric poles onto the ground.
- Never fly a kite or climb trees near electric power lines.
- Never touch bare wires in electric appliances.

Chapter Review

- Charging by contact (conduction) involves the flow of electrons through one object to another object.
- An electroscope charged by contact takes on the same charge as the charging object.
- Charging an object by induction requires no contact with the object inducing the charge.
- A conductor charged by induction would end up with an opposite charge to that of the inducing object.
- A positively or negatively charged object becomes neutral upon discharging.
- Induction involves a rearrangement of electric charges.
- Grounding is electrically connecting an object to earth to eliminate excess charge.

Insights

Lightning

Lightning is a large discharge of static electricity. The friction from the movement of water droplets in a cloud can build up areas of positive and negative charges. The bottom position of a cloud develops a negative charge causing a positive charge to be induced

Fig. 31 Thunder cloud.

on earth surface. As the difference in charge increases, electrons jump from the cloud to the earth. The result of this transfer of electrons is a giant spark called lightning. Lightning can also occur as electrons jump from cloud to cloud. As electrons jump through the air, intense light and heat are produced. The light is the bolt of the lightning you see. The heat causes the air to expand suddenly. The rapid expansion of the air is the thunder you hear. Lightning can cause power outages, injury or loss of life and fire.

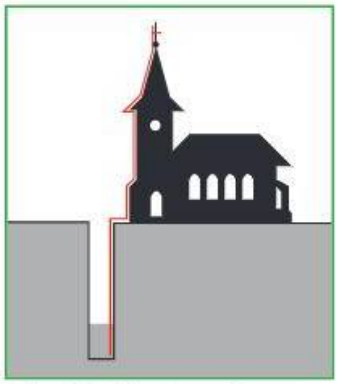


Fig. 32 Lightning rod.

Science and Society

1. Lightning Rod

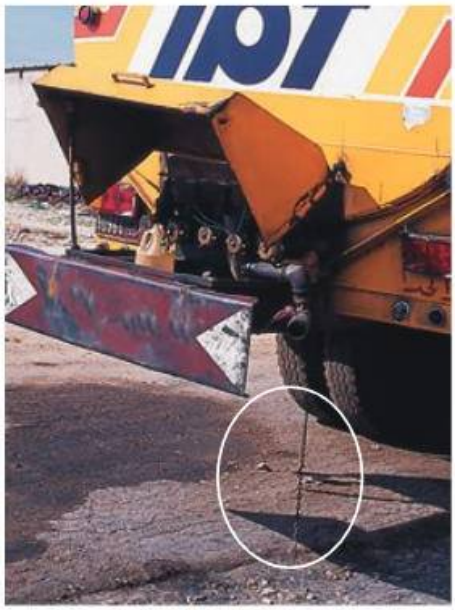


Fig. 33 Ground wire on a fuel truck.

Lightning rods work according to the principle of grounding (earthing). A discharge of static electricity usually takes the shortest path from one object to another.

Lightning rods are attached to the tops of buildings and a wire connects the lightning rod to a metal plate deep in the ground to ensure good grounding.

2. Chains Suspended from Gasoline Tanks

Fuel trucks tend to build up charge by friction as they dispense fuel. If this charge were to jump to earth through gasoline vapor, it could cause an explosion. Instead, an earthed metal wire usually a suspended chain, connected to the truck's body, safely conducts the charge to ground.

Questions and Exercises

I- Write the word(s) that best complete(s) each statement.

1. When the knob of an uncharged electroscope is touched by a negatively charged rod, the electroscope..... electrons and becomes..... charged.
2. A positively charged rod brought near, but not touching, the knob of a negatively charged electroscope will cause the leaves to.....
3. If a positively charged rod is brought near, but not touching the knob of a positively charged electroscope, it will cause the leaves to.....
4. The elimination of excess accumulated charges on an object is called.....
5. The lightning rod was invented to..... a building from lightning damage.
6. Ground wire on a fuel truck..... conducts the charge to the ground.

II- Circle the letter of the answer that best completes each statement.

1. When the knob of an uncharged electroscope is touched by a positively charged rod, the leaves of the electroscope:
   a) gain electrons
   b) lose electrons
   c) remain neutral
   d) gain protons
2. As a negatively charged body is brought near the knob of an uncharged electroscope without touching it, electrons will move from:
   a) the leaves to the knob
   b) the knob to the leaves
   c) the knob to the negatively charged body
   d) the negatively charged body to the knob.
3. As a negatively charged body is brought near, but not in contact, with the knob of a negatively charged electroscope, the leaves will:
   a) gradually come together
   b) spread farther apart
   c) first spread apart, then come together
   d) first come together, then spread apart
4. To charge an electroscope by induction, the charge inducing object should:
   a) be in direct contact with the knob of the electroscope.
   b) not be in direct contact with the knob of the electroscope.
   c) not be in direct contact with the knob of the electroscope and grounding is necessary.
   d) be neutral.

III- Answer the following questions:

1. Explain how to charge an electroscope positively by contact. How do the leaves of the electroscope indicate that the electroscope possesses electric charges?
2. State what happens and interpret the results when:
   a) the knob of the neutral electroscope is brought near a rubbed ebonite rod which is then removed.
   b) the rubbed ebonite rod is rolled on the knob of the electroscope and then removed.
3. What is necessary for lightning to occur between a cloud and the earth?
4. What are the main hazards that may accompany a bolt of lightning?
5. Use the following materials to construct an electroscope: Metallic wire, rubber stopper, aluminum foil and a large Erlenmeyer flask.

Unit two

PURE SUBSTANCES

Fig. 1 Alchemy in the medieval period.

Unit Overview

Matter is all around us. It makes up every living and non-living thing we see or use. Matter can be a pure substance. Pure substances can be elements and compounds. The building blocks of elements and compounds are atoms, ions and molecules. Chemists have developed a system of naming compounds according to the elements that compose them and the way the atoms of these combine to form the corresponding compounds.

Contents

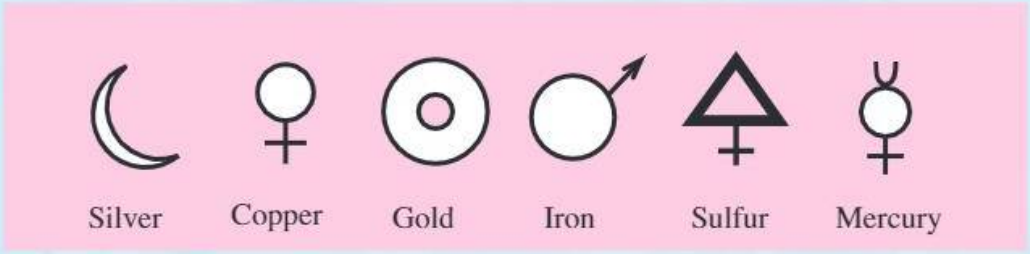


Fig. 2 The alchemists used symbols like these to represent elements.

Fig. 3 A droplet of the element mercury can be divided into smaller and smaller droplets, each possessing all the properties of mercury.

Fig. 4 Samples of some common chemicals.

CHAPTER *I*

Classification of Substances

Chapter Overview

Elements and compounds are pure substances. Every pure substance has a unique set of physical and chemical properties. Compounds can be broken into simpler substances, but elements cannot.

Elements may consist of single atoms or molecules; generally they can be classified into metals and non-metals.

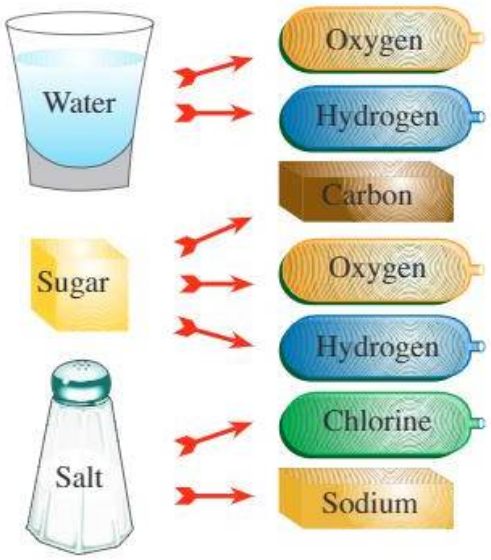


Fig. 5 Compounds are made up of elements.

Chapter Contents

1 Pure Substances

Substances can be identified by recognizing their properties. A property is a characteristic of a substance. Every substance has two kinds of properties: physical and chemical.

Knowing these properties allows us to identify and distinguish one substance from another.

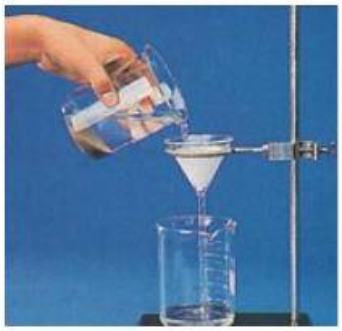


Fig. 6a Filtring apparatus.

1.1. Separation of Pure Substances

Activity 1

Materials:

- Aluminum foil
- Spatula
- 2 Watch glasses
- Scissors
- 2 Stirring rods
- Distilled water
- Filtering apparatus
- Sodium chloride
- Heating apparatus
- 4 Beakers (250 mL)

Fig. 6b Heating apparatus.

Procedure:

- Using scissors, cut the aluminum foil into small pieces and put some of these pieces on a watch glass as a control sample.
- Put the remaining aluminum pieces into a beaker (A), containing 30 mL of distilled water, and stir.
- Using a spatula, put some sodium chloride on a watch glass and keep it as a control sample.
- Put some sodium chloride in a beaker (B) containing 30 mL distilled water and stir.
- Filter the contents of beakers (A) and (B) into beakers (C) and (D) respectively.
- Carefully, heat each filtrate almost to complete dryness.

Stand, ring, filter paper, funnel, and receiving flask (beaker).

Tripod, stand and ring, wire-gauze, Bunsen-burner.

Safety

Stop heating when some water remains in each beaker.

Analysis:

1. What changes took place after stirring the content of each beaker?
2. Is there any residue on the filter paper after filtering the content of each beaker?

   If yes, compare the residue to the control sample on the watch glass.
3. What do you observe upon evaporating, the filtrates collected in beakers (C) and (D)?
4. If there is a residue, compare it to the control samples kept on the watch glasses.

Conclusion

- Pure substances cannot be separated into simpler substances by applying physical separation techniques, such as: filtration and vaporization.
- Separation techniques: filtration, vaporization, distillation, decantation and other procedures involve physical change.
- A physical change is a change that occurs in the form of a substance without causing a change in the identity of the substance.

1.2. Identifying a Pure Substance by Its Physical Properties

Physical properties of a substance are characteristics that the substance exhibits without any change in its identity. Some physical properties are measurable. These properties are called physical constants. They are used as criteria for the purity of the substance.

Activity 2a

Materials:

- 2 Beakers (250 mL)
- Distilled water
- Sodium chloride
- Stirrer
- Heating apparatus
- Spatula
- Attach clamp
- Thermometer
- Boiling chips
- Rubber stopper with one hole

Procedure:

- Fill approximately 100 mL water in each of the two beakers (A) and (B).
- Add 2-3 boiling chips to the water in each beaker.
- Dissolve about (15 g) sodium chloride in beaker (B).
- Set up the apparatus for boiling as indicated in (Fig. 7).
- Using attach clamp, suspend the thermometer so that it is dipping half way into the water of beaker (A).
- Heat the water to boiling and record the thermometer reading (T_1).
- Allow the thermometer to stand for 1 minute in the boiling water and record the thermometer reading (T_2). Wait for one more minute and record the thermometer reading (T_3).
- Turn off the Bunsen burner and allow the beaker to cool, then remove it from the heating apparatus.

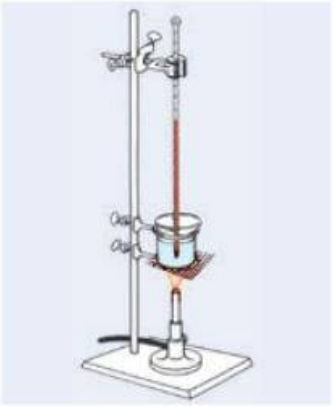


Fig. 7 Boiling salty water.

Activity 2b

Repeat the procedure described in Activity 2a, using beaker (B), instead of beaker (A).

Analysis:

1. Copy the following table in your copybook and complete it.

Boiling point	T_1 °C	T_2 °C	T_3 °C
Liquid in beaker (A)			
Liquid in beaker (B)			

2. Is the appearance of the liquid in beaker (A) the same as that of the liquid in beaker (B)?
3. Is the boiling temperature of each of the two liquids in beakers (A) and (B) the same?
4. Which liquid has a variable boiling point? Why?

Remark

- Other physical techniques, such as distillation, show the same result.
- Make certain that the thermometer is freely suspended in water and is not touching the walls nor the bottom of the beaker.

Safety

Test for odor (smell).
Some vapors are toxic or irritating.
Fan the vapor toward your nose.
Never hold your nose directly over the vessel.

Activity 3

Materials:

- (500 mL) Beaker
- Mothball Flakes
- Heating apparatus
- Water
- Large test tube
- (2) Thermometers
- Spatula
- (2) One hole rubber stopper
- 2 Attach clamps

Fig. 8 Melting of mothball flakes. Thermometer (T_1) reads the temperature of mothball flakes, and thermometer (T_2) reads the temperature of the water bath.

Procedure:

- Fit each of the two thermometers (T_1) and (T_2), to a one-hole rubber stopper.
- Fill 1/3 of the beaker with water.
- Put some mothball flakes in the large test tube.
- Using an attach clamp, suspend thermometer (T_1) into the water bath. Make certain the thermometer is not touching the walls or bottom of the beaker.
- Stopper the large test tube with the one-hole rubber stopper fitted with thermometer (T_2) and fix it to the stand using an attach clamp. Make certain that the bottom of the tube is not touching the base of the beaker (Fig. 8).
- Heat the water. Record the temperature readings of both thermometers when all the solid mothball flakes turn to liquid.
- Turn off the heating source when the thermometer (T_2) reads about 85°C.
- Allow the water to cool. Record the temperature readings of both thermometers when the liquid mothball flakes turn to solid (freezes).

Analysis:

1. What is the observed a) melting point of mothball flakes?
   b) freezing point of mothball flakes?
2. Is the melting point of the mothball flakes the same as its freezing point?
3. Does the «new» solid have the same smell as the original mothball flakes?
4. What do you conclude?

Glossary

- ***Melting point:*** The temperature at which a solid starts changing to a liquid.
- ***Freezing point:*** The temperature at which a liquid starts changing to a solid.

Conclusion

- Pure substances are characterized by specific measurable physical quantities, such as: density, boiling point, melting point.
- The measurable physical quantities of a pure substance are «constant values» and are independent of the mass of the sample used.

Remark

The measureable physical quantities of a pure substance are known as physical constants.

2 Elements and Compounds

Matter that surrounds us is composed of simple substances called elements. The elements are sometimes found in the free state, but more often they are in the combined state.

2.1. Decomposition of a Compound

Activity 4

Materials:

- Heating apparatus
- Large test tube
- Mercuric oxide
- Wooden splint
- Spatula
- Attach clamp

Safety

Perform this experiment in a well-ventilated room.

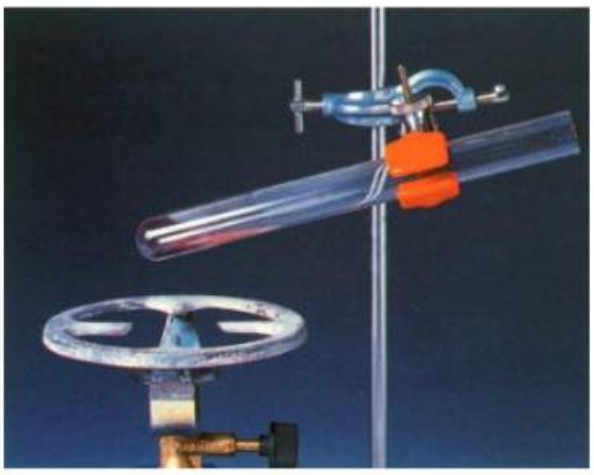


Fig. 9a Decomposition of mercuric oxide.

Fig. 9b Identifying the gas released.

Procedure:

- Using the spatula, put some mercuric oxide in a large test tube.
- Tap the test tube to spread the oxide then clamp it in a tilt position, (Fig. 9a).
- Heat gently at first, then heat strongly the tube.
- Lower a glowing wooden splint into the test tube, 1 cm below the mouth of the tube (Fig. 9b). Observe what happens.

Analysis:

1. What do you observe at the bottom of the test tube after heating?
2. What happens to the glowing wooden splint? What does this indicate?
3. Has any new or simpler substance(s) been formed? Name them.
4. Is the identity of the simpler substances produced the same as that of the original substance?
5. What kind of change did mercuric oxide undergo?

Glossary

Chemical change:
A chemical change is a change by which the identity of the substance changes.

Conclusion

- Pure substances can be classified on the basis of their properties into elements and compounds.
- An element is a pure substance that cannot be broken down into simpler substances by heating or by any chemical change.
- A compound is a pure substance that can be broken down into two or more simpler pure substances by a chemical change.

Compounds → **Chemical Change** → **Elements**

2.2. Selected Common Elements and Compounds

Elements are nature's building blocks. Most elements are solids, but some are gases and a few are liquids.

Oxygen and nitrogen in air are elements. Mercury, silver, sulfur, iron and magnesium are elements too.

Fig. 10 Gold is a very rare element. The attractive appearance of gold and its resistance to corrosion have led to its use for ornaments and as currency.

Fig. 11 Silicon is a semi-metal (metalloid). It is used for the manufacture of «silicon chips» for electronic appliances, such as computers.

Fig. 12 Helium is a colorless, odorless, and nontoxic gas. It has a low density. It is used for filling balloons and in mixtures with oxygen for deep sea diving.

Fig. 13 Mercury is the only metal that is liquid at room temperature. It is used in thermometers, barometers, and in dental amalgam (mostly with tin) for filling teeth.

Glossary

Semi-metals have properties that are intermediate between metallic and non-metallic properties.

Although there are only 111 elements, millions of compounds are known. These elements combine together providing the great number of compounds that make up our world. For example: the clothes you wear, the food you eat, the toothpaste you use, the hemoglobin that carries oxygen in your blood, the water you drink. You can add any number of items to this list.

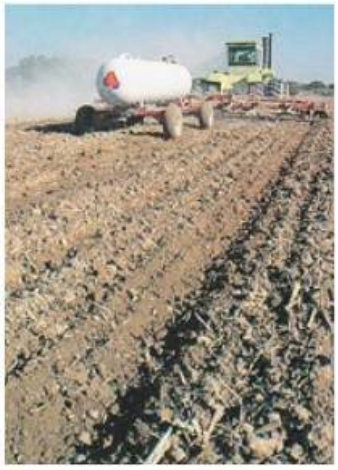


Fig. 14 Ammonia is used in fertilizers and household cleaners, when dissolved in water. Ammonia is composed of hydrogen and nitrogen.

Fig. 16 Water is an essential compound for all living things. No other substance can naturally exist in solid, liquid and gaseous state.

Fig. 15 Baking soda (sodium bicarbonate) is used in baking. It is composed of sodium, carbon, hydrogen and oxygen.

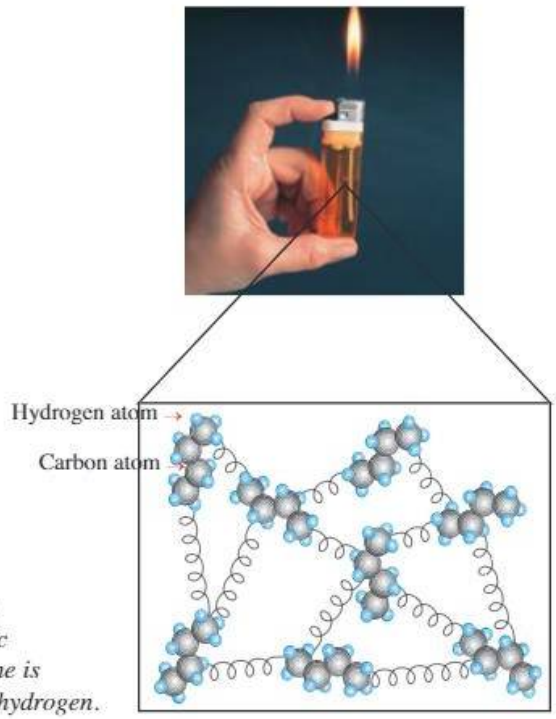


Fig. 17 Butane is the fuel commonly found in plastic disposable lighters. Butane is composed of carbon and hydrogen.

Activity 5

Classify the following chemicals into elements and compounds.

(Copy the table given below in your copybook).

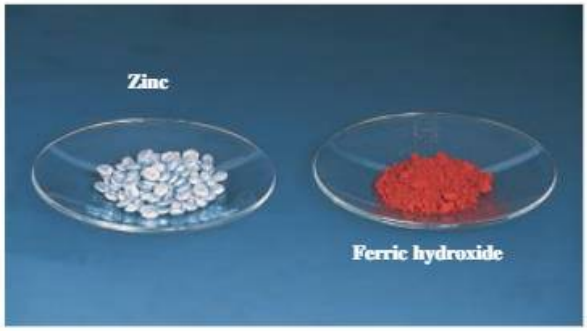


Fig. 18a

Fig. 18b

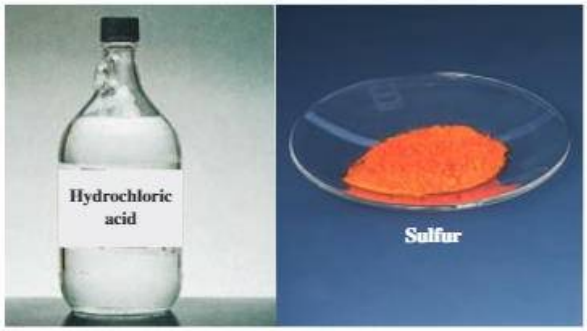


Fig. 18c

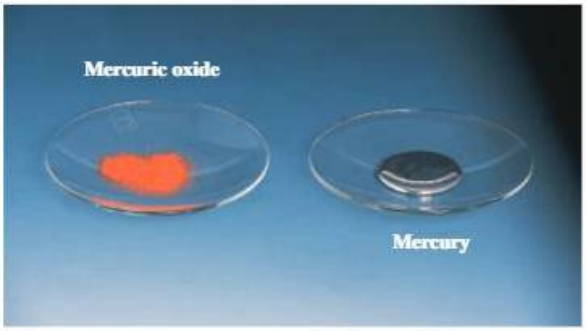


Fig. 18d

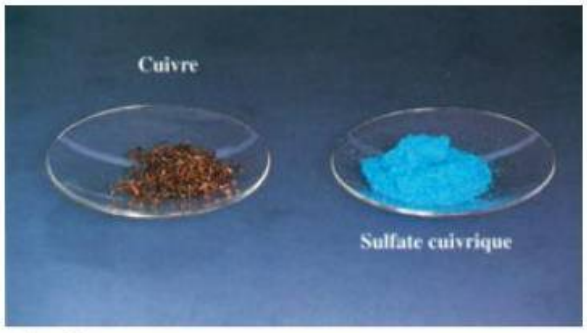


Fig. 18e

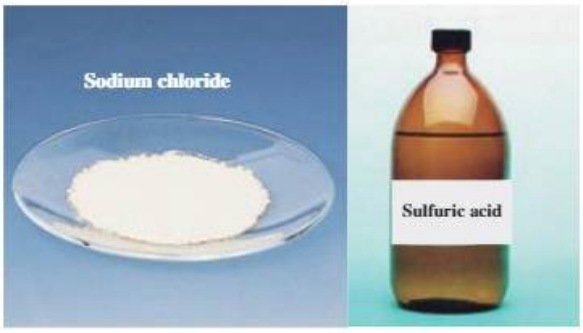


Fig. 18f

Elements	Compounds
Chlorine	Sulfuric acid

3 Metals and Non-metals

When you hear the word metal, you probably think of such familiar substances as iron, copper, silver or aluminum. These elements indeed are metals. But elements you may not have thought of as metals such as calcium, sodium, magnesium, gallium and nickel are also classified as metals.

Although the majority of elements are metals, many non-metals are abundant in nature. The non-metals oxygen and nitrogen make up 99 percent of the earth's atmosphere.

Carbon, another non-metal, is found in more compounds than all the other elements combined.

Safety

The element phosphorous is very toxic. It must be handled carefully.

Phosphorous, sulfur, chlorine, bromine and iodine are non-metals too.

Bromine is the only non-metal that is liquid at room temperature.

Fig. 19 White phosphorous is stored under water because it ignites in air.

Fig. 20 Naturally occuring crystals of sulfur.

Fig. 21 Gaseous chlorine, liquid bromine, and solid iodine.

3.1. Properties of Metals and Non-metals

Glossary

- **Extensive property** depends upon the amount of matter present.
- **Intensive property** does not depend upon the amount of matter.

The same properties used to describe matter in general can be used to describe elements in their pure form. The physical properties may be divided into two groups:

- Extensive properties such as mass, length, and volume.
- Intensive properties such as density, boiling and melting points, electrical and heat conductivity.

A- Characteristic properties of metals

- All metals, except mercury, are solids at room temperature.
- Metals are shiny. When polished, or freshly cut, they have usually a surface that reflects light; a quality called luster.
- Metals are malleable. Malleability is the ability to be hammered or beaten into thin sheet.
- Metals are ductile. Ductility is the ability to be drawn into a thin wire.
- Metals are good conductors of heat and electricity.
- Most metals are hard and have high melting points, but there are many exceptions. For example, sodium is soft. Pure gold is relatively soft; this is why pure gold cannot be used alone in jewelry. It is mixed with other metals to form gold alloys that are more durable. The element gallium has very low melting point and mercury is liquid at room temperature.

Fig. 23 The melting point of gallium is 29.8°C. Body temperature is 37°C, which is enough to cause the metal to melt in the palm of your hand.

Fig. 22 Metals can be drawn into wires. The gauge of the wire is related to its thickness.

Fig. 24 Iron, like other metals, is hammered. It can be flattened and stretched.

B- Characteristic properties of non-metals

- Non-metals do not have luster, so they look dull.
- Many non-metals are gases at room temperature. Solid non-metals are brittle; they are easily broken such as sulfur.
- Solid non-metals cannot be hammered into different shapes nor drawn into wires.
- Non-metals are poor conductors of heat and electricity.
- Non-metals have, in general, low melting and boiling points.

Fig. 25 Sulfur has properties characteristic of non-metals. Although solid, it is brittle.

3.2. Properties of Selected Elements and a Compound

Sulfur

- A dull, yellow non-metal
- Brittle
- Shatters when hammered
- Poor conductor of heat and electricity
- Density 3.1 g/cm^3
- Melting point 113°C
- Used in gunpowder, rubber, fungicides,...

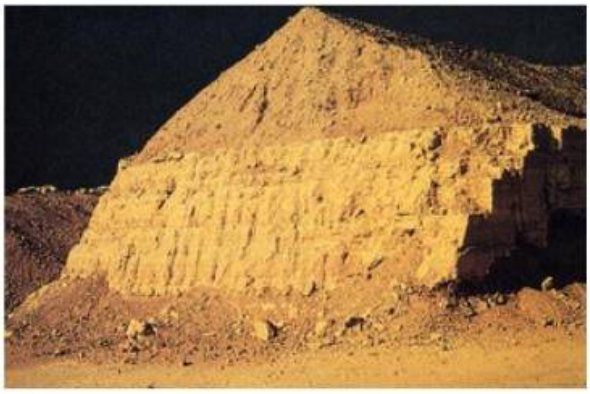


Fig. 27 Sulfur is found in nature, a deposit of sulfur.

Sodium chloride

- Sodium chloride, or table salt, is a brittle white solid.
- Has high melting point, 801°C.
- Conducts electricity in the molten state and when dissolved in water.
- Used in industry: in producing dyes, soap, plastics and other products.

Fig. 28 Sodium chloride cleaves in different directions when hammered.

Fig. 26 Silver tableware.

Silver

- Density 10.5g/cm^3
- Melting point 962°C
- Good conductor of heat and electricity
- A shiny metal
- Extremely ductile
- Can be hammered into sheets, malleable.
- Used in coins, jewelry, tableware,...

Activity 6

Conduct a research about some common elements and a compound. (Use the information found on this page as an outline for your research).

3.3. Uses of Selected Metals and Non-metals

Although metals have a lot of similarities, they have also a lot of differences in their properties. These differences are important when deciding which metal to use for which purpose.

For centuries, copper, silver and gold have been used as coins. For this reason they are known as coinage metals. Gold and silver have luster and are very malleable and ductile; they are also used in jewelry. Copper is often used in electric wires due to its superior ability to conduct electricity.

Fig. 30 Solder (an alloy of lead and tin) can be melted with a hot iron to join electrical components without damaging them.

Fig. 29 Brass tableware.

Copper is alloyed with other metals to give copper alloys. Brass is an alloy of copper and zinc. Brass is used in water pipes and also to make tableware.

Titanium has low mass and resists corrosion. It is used in jet engines and missiles. Also, because it does not react with flesh or bone, titanium is used to make surgical pins.

Cadmium is used in rechargeable batteries. A nickel-cadmium battery can be recharged an indefinite number of times. The nickel-cadmium battery can be sealed to prevent leakage which is particularly important for electronic devices such as calculators, power tools and others.

Non-metals have varying properties. They, too are used for different purposes.

The halogens chlorine, bromine, and iodine are used in the bulbs of halogen lamps.

The odor near swimming pools is the odor of chlorine. Chlorine compounds are used to disinfect water. Household and industrial bleaches, used to whiten the floor and paper, contain also chlorine compounds.

Dyes in some cosmetics contain bromine compounds.

Fig. 31 A hip joint constructed from titanium alloy metal.

Fig. 32 Tincture of iodine.

Tincture of iodine, a solution of alcohol and iodine, is a familiar antiseptic used to treat cuts and scrapes.

When high voltage is passed through a tube containing neon gas, it produces a distinct red light. So, it is useful for advertising signs.

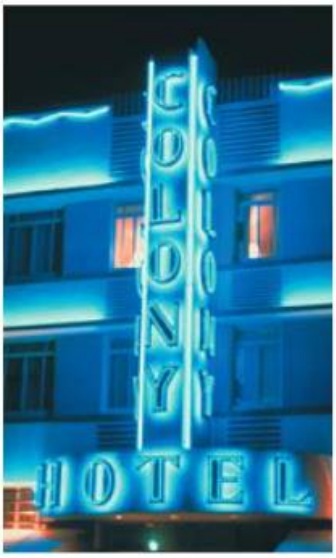


Fig. 33a Neon signs.

Fig. 34 Neon lamp.

Remark

The term «neon sign» can be misleading, for neon signs may contain gases other than neon. Mixtures of gases may also be used to produce different colors.

Activity 7

Compare the Properties of a Rusted Iron Nail and a Shiny Iron Nail.

Bring to class a polished iron nail and a completely rusted iron nail.

Compare their properties and tabulate your observations in your copybook.

Fig. 35 Rusted iron. The formation of rust weakens the metal.

Properties	Polished iron nail	Rusted iron nail
1. color		
2. luster		
3. malleability		

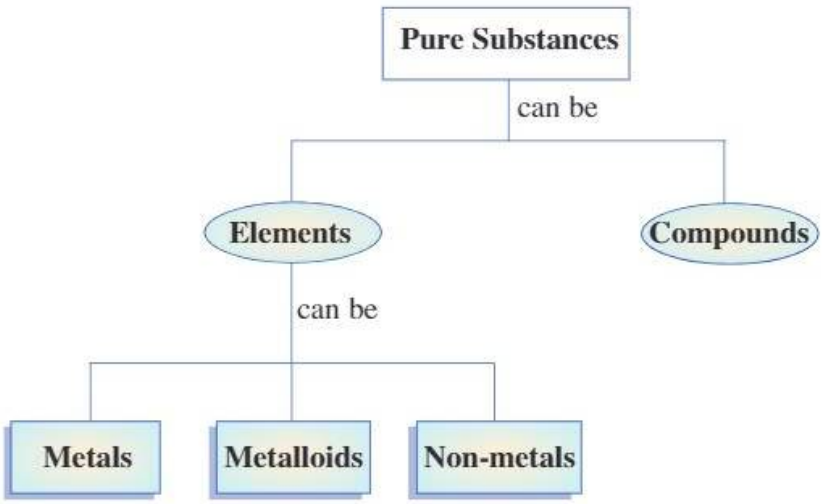
Conclusion

- Iron and rust have different properties.
- Iron is an element, while rust is a compound.
- Rust is formed as a result of the reaction of iron with humid air.

Chapter Review

- Pure substances cannot be separated into simpler substances by applying physical separation techniques.
- A physical change is a change in the form of a substance without a resultant change in the identity of the substance.
- Pure substances are characterized by specific measurable physical quantities such as density, boiling and melting points, and others.
- Pure substances can be elements and compounds.
- An element is a pure substance that cannot be broken into simpler substances by heating or by a chemical change.
- A compound is a pure substance that can be broken down into two or more simpler pure substances by a chemical change.
- In general, elements can be metals or non-metals. Some elements are metalloids (semi-metals).
- Metals have luster, are malleable, are ductile and are good conductors of heat and electricity. They have high densities, high melting and boiling points.
- In general, non-metals do not have luster, are not malleable, are not ductile, and are poor conductors of heat and electricity. They have low density, low melting and boiling points.

Concept Mapping



Insights

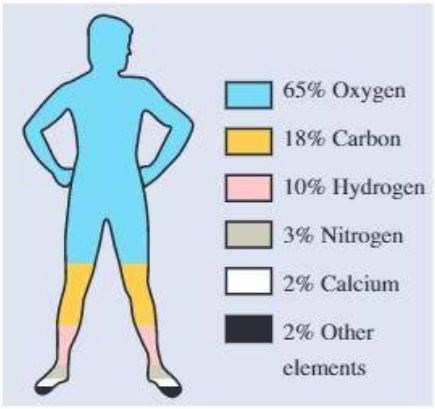


Fig. 36 Distribution of biologically important elements in the human body, (relative percentages by mass).

1. Biologically Important Elements in the Human Body

Carbon, nitrogen, oxygen, sulfur and phosphorous. These five non-metals together with hydrogen make up much of your body. They form fats, carbohydrates, proteins and nucleic acids — the building blocks of living things.

2. Environment and Toxic Metals

Cadmium and mercury are both toxic metals.

Mercury compounds can accumulate in the body.

People have died of mercury poisoning from eating fish from contaminated water.

Metals are among industrial waste products that pollute the environment.

3. Relative Percentages by Mass of Elements in the Earth's Crust

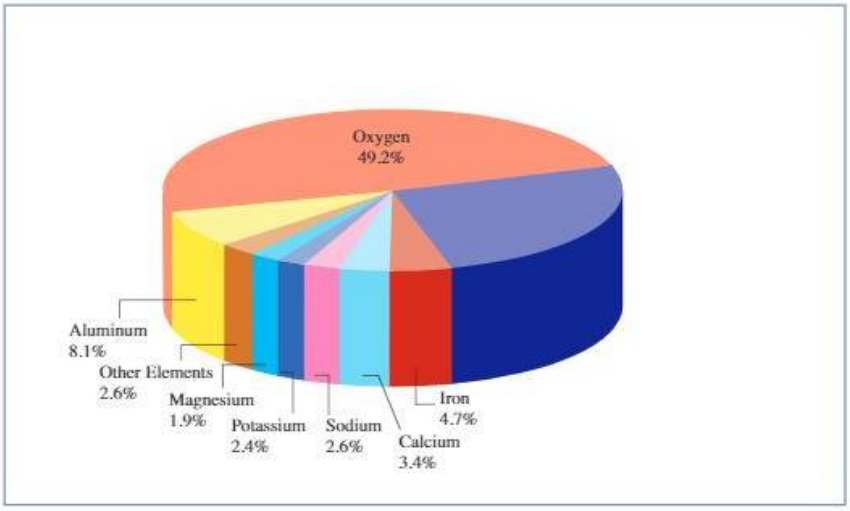


Fig. 37 "Pie-chart" (circle graph) giving relative percentages by mass of various elements in the earth's crust.

Science and Society

1. The Halogen Lamps

Halogen lamps contain metal halides – chemical compounds of a metal and a halogen. These compounds produce a more natural color than other lamps. Halogen lamps also last longer and produce more light for the same amount of electrical input. For these reasons, halogen lamps are excellent light sources for outdoor use.

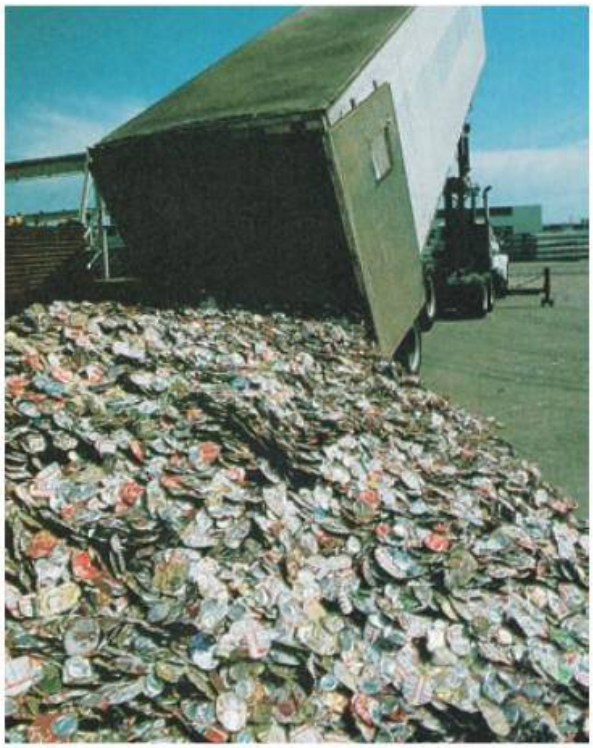
They are also commonly used in car headlights.

Fig. 38 Halogen lamp.

2. Recycling of Aluminum

Aluminum cans are used in the beverage industry. The reasons for aluminum popularity is that it is non-toxic, odorless, tasteless, light in mass, and the liquid inside the container can be chilled rapidly.

The metal cans, when discarded, litter the countryside of our throw-away society. The best solution to this environmental problem and the way to prevent the rapid depletion of a finite source is recycling.



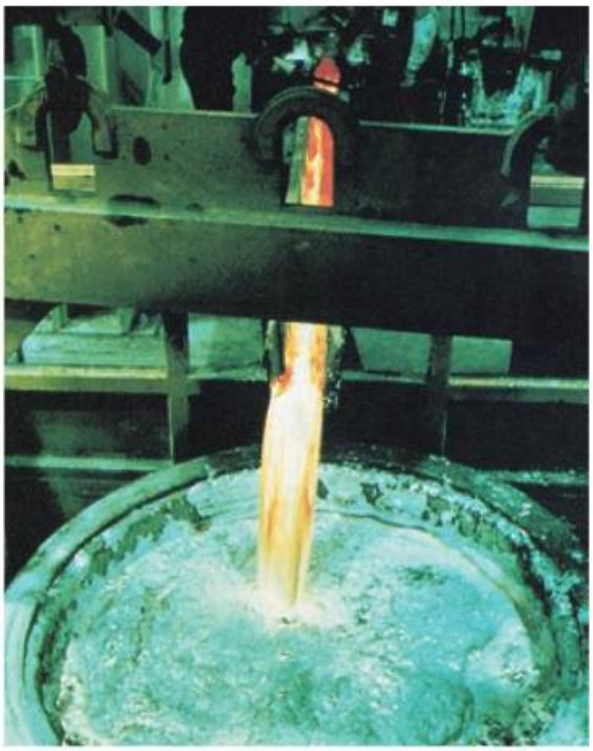


Fig. 39 Recycling of aluminum.

Questions and Exercises

I- Write the word(s) that best complete(s) each statement.

1. An..... is a substance that cannot be broken into simpler substances.
2. It is possible to make silver wire because silver is.....
3. All..... are good conductors of heat and.....
4. The density of a pure substance is always the..... under the same conditions.
5. A compound is made up of more than one.....
6. The properties of a compound are..... from the properties of the elements that form it.
7. Pure substances..... be separated into simpler substances by applying physical separation techniques such as..... and vaporization.
8. A physical change is a change in the form of a substance..... a resultant change in the..... of the substance.
9. Melting and boiling points of a pure liquid are..... physical quantities, whereas mass and volume are..... physical properties.
10. A compound is a..... that can be broken down into..... or..... simpler pure substances by a..... change.

II- Write «T» if the statement is true and «F» if it is false.

1. An element is characterized by its own unique set of physical constants.
2. A pure substance that cannot be broken down by heat or chemical change is a compound.
3. Metals that can be drawn into wires need not necessarily be malleable.
4. Metals are good conductors of heat and electricity.
5. Non-metals are not elements, they are compounds.
6. The physical constants of a pure substance depend on the mass of the sample used.
7. Copper and brass have the same density.
8. Iron and steel are metallic elements.
9. Solid sulfur is brittle, and good conductor of heat.

III- Circle the letter of the answer that best completes each statement.

1. The elements copper and iron are:
   a) non-metals
   b) coinage metals
   c) alloys
   d) metals
2. A pure substance can be identified according to its:
   a) physical appearance
   b) conductivity to electricity
   c) color
   d) measurable physical properties
3. Mercuric oxide is a compound because it is composed of:
   a) oxygen gas
   b) mercury which is liquid metal
   c) mercury and oxygen
   d) a liquid and a gas

4. When, an iron nail is exposed for a long time to humid air, rust which forms:

   a) is non metal

   b) has the same properties as iron

   c) is an element

   d) is a compound

5. In general, all metals are:

   a) insulators

   b) brittle

   c) liquids except mercury which is solid

   d) conductors of electricity

IV- Match the terms of column (A) to those in column (B).

Column (A)	**Column (B)**
1. Mercury	a) decomposition of a compound
2. Oxygen	b) malleable and ductile
3. Bromine	c) nonmetal, liquid at room temperature
4. Mercuric oxide	d) compound
5. Silver	e) metal, liquid at room temperature
6. Chemical change	f) does not have a definite volume

V- Answer the following questions

1. Distinguish between extensive and intensive properties. Give three examples of each.

2. The percentages, by volume of the elements composing the earth's atmosphere are given in the table below.

Element	Nitrogen	Oxygen	Argon	Other elements
Percent by volume	78	21	0.9	0.1

Represent the given values using:

a) Circle graph b) Bar graph (histogram)

3. You are given a piece of the element zinc. How would you test it to see if it is a metal?

4. We encounter examples of metals nearly everywhere. Write a paragraph describing how a specific metallic element has an effect in your life.

5. Given the following pair of elements, name two physical properties that could be used to distinguish between each of the paired elements.

   a) Copper and silver

   b) Mercury and bromine

6. Choose three elements you are familiar with. List 3 properties of each and describe where the element is used.

7. Write the names of five compounds you are familiar with.

   List the elements each contains. Name the element that is common to the five compounds, if there is any.

8. Is every clear liquid a pure substance? How can you verify experimentally whether it is pure or not?

9. Although aluminum is more abundant than iron, conduct a research to find out why iron is cheaper than aluminum.

10. Conduct a library research on two elements that may be found free in nature.

    List three physical properties of each and relate their uses to these physical properties.

CHAPTER *II*

Structure of Matter

Atoms, Molecules and Ions

Chapter Overview Atoms, molecules, and ions are the building blocks of elements and compounds.

Atoms of an element contain a definite number of protons in their nuclei.

Molecules are combinations of atoms.

Ions can be classified into monoatomic and polyatomic ions.

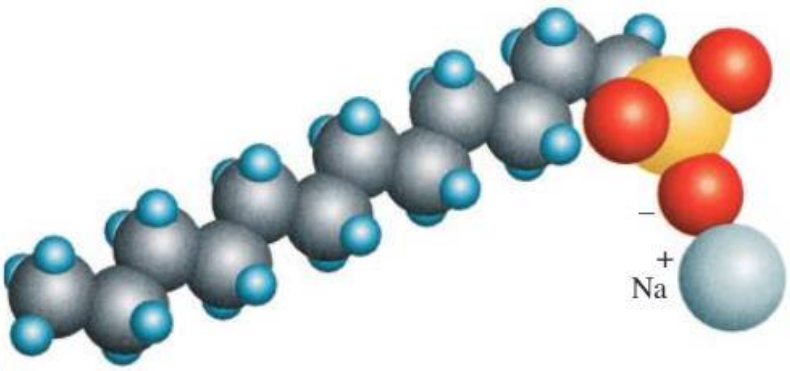


Fig. 40 The long molecule of sodium lauryl sulfate is found in detergents. An oxygen atom connects the carbon chain to a sulfate ion, which is ionically bonded to a sodium ion.

Chapter Contents

1 Atoms

1.1. The Hidden Structure of Matter

Water is a compound composed of the elements hydrogen and oxygen.

Each element is composed of one kind of tiny particles called atoms.

Each kind of atom has unique properties.

An atom of an element cannot be broken down by chemical means.

The particles of matter can be made up of single atoms, two atoms of the same element or of different elements (molecules), or can be made up of ions.

Fig. 41 Variety of colors of «neon signs»
A noble gas is made up of one kind of atom.

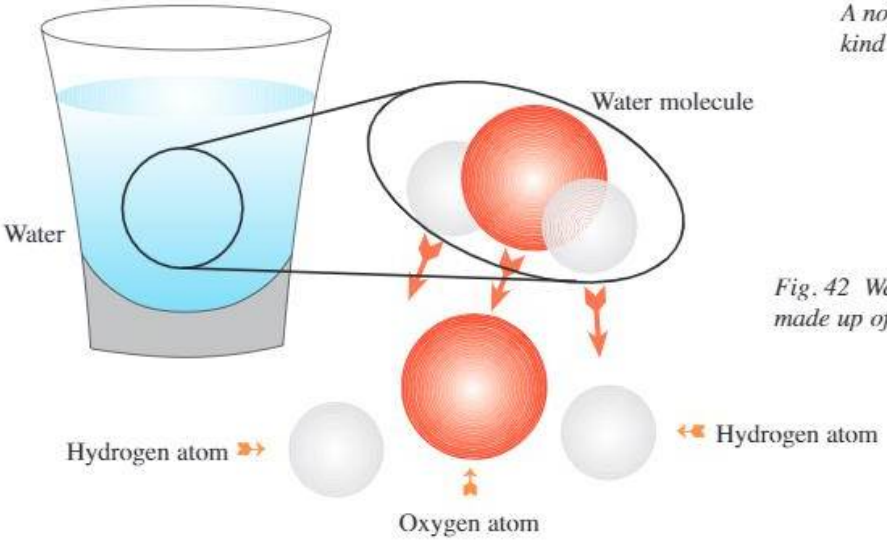


Fig. 42 Water particles are made up of two kinds of atoms.

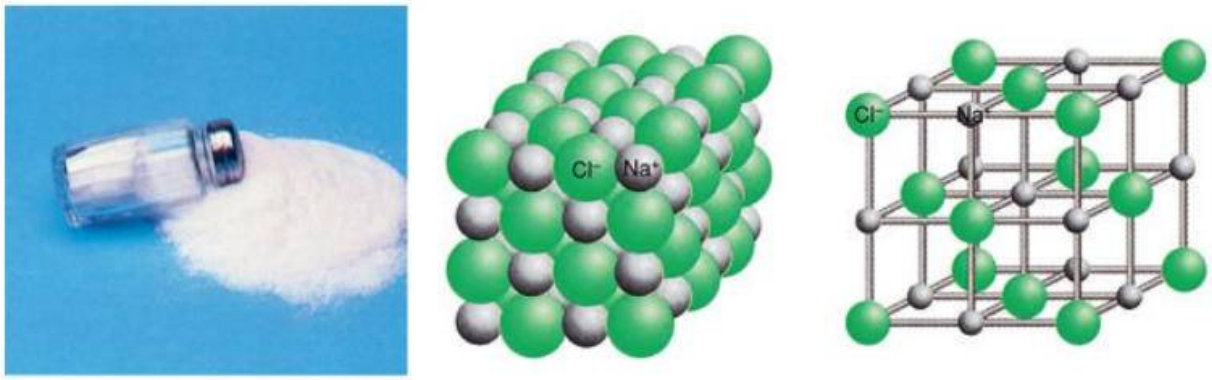


Fig. 43 Sodium chloride is made up of two kinds of ions. The diagram shows sodium ions (gray) and chloride ions (green).

1.2. Fundamental Subatomic Particles

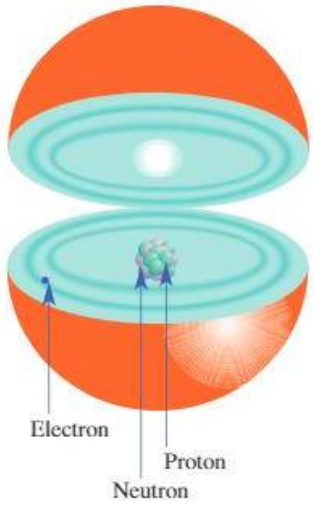


Fig. 44 The diagram shows the location of subatomic particles in an atom.

In today's atomic model, an atom has a small positively charged massive nucleus.

The nucleus contains positive particles called protons and neutral particles called neutrons.

The nucleus is surrounded by a large region called electron cloud, in which there are enough electrons to make the atom neutral.

Electrons are negatively charged particles.

The mass of a proton is considered to be equal to that of a neutron and is equal to almost 1840 times the mass of an electron.

The Fundamental Subatomic Particles – Summary

Particle	charge	mass compared to mass of electron	Location
proton	positive (+)	almost 1840 times as massive	in the nucleus
neutron	neutral	almost 1840 times as massive	in the nucleus
electron	negative (-)	—	outside the nucleus

1.3. Definition of an Atom

An atom is the smallest entity of an element that retains the chemical identity of the element. It is made up of neutrons, and of equal numbers of charged particles: protons and electrons.

1.4. Atomic Number

The number of protons in the nucleus of an atom determines the identity of the element. This number is called the atomic number of the element and it is denoted by the letter Z.

The nuclei of helium, beryllium and sodium atoms all contain protons and neutrons. Yet, helium, beryllium and sodium are different elements.

The atomic number of Helium is Z = 2, that of Beryllium is 4, and that of Sodium is 11.

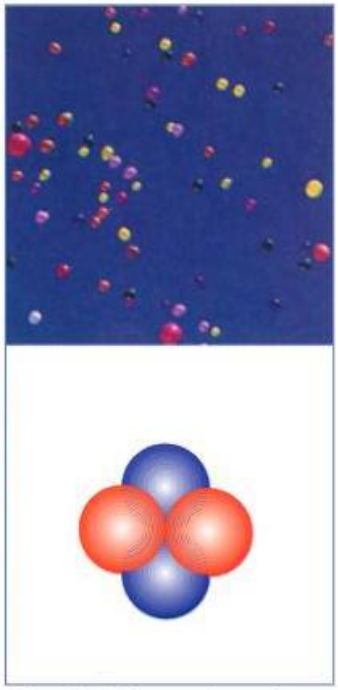


Fig. 45a The atomic number of Helium Z = 2

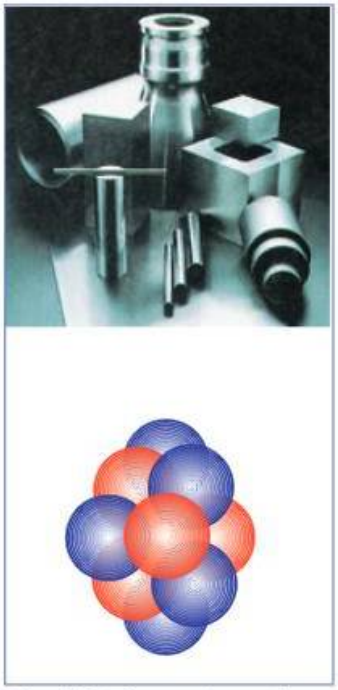


Fig. 45b The atomic number of Beryllium Z = 4

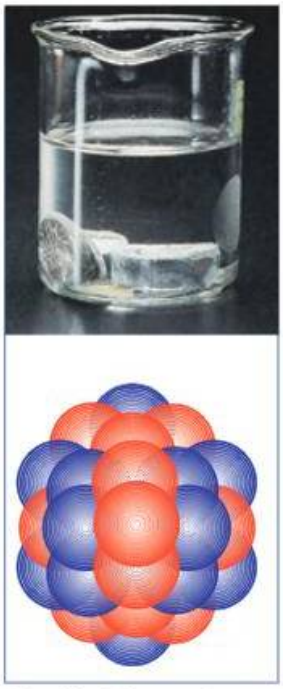


Fig. 45c The atomic number of Sodium Z = 11

2 Molecules

In many compounds and in some elements, atoms are bound together to form molecules.

We cannot directly observe molecules because of their extremely small size. An effective way to visualize molecules is by the use of models.

2.1. Definition of a Molecule

A molecule is a neutral group of atoms that act as a unit.

2.2. Construction of Some Molecules

Diatomic Molecules

Some elements occur in nature as diatomic molecules such as oxygen and nitrogen. They are called molecular elements. However, some compounds occur as diatomic molecules, too, such as carbon monoxide, and hydrogen chloride.

Activity 1

Materials:

- Modeling clay, or molecular models.

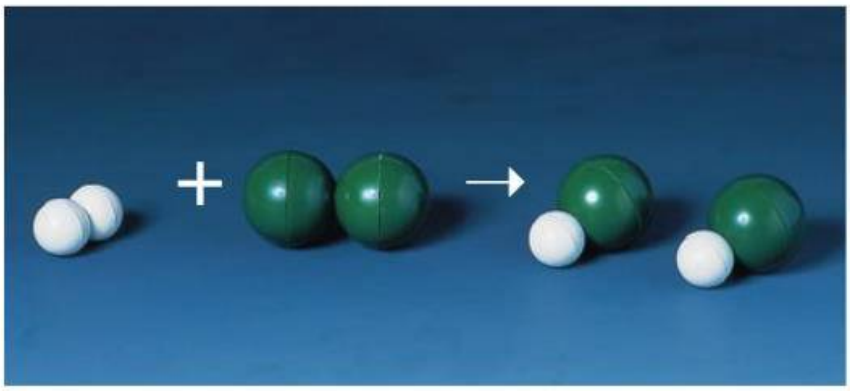


Fig. 46 Molecular models of chlorine, hydrogen and hydrogen chloride.

Procedure:

- Construct, using modeling clay, the molecules of hydrogen, chlorine and hydrogen chloride.
- Also, construct the above mentioned molecules using molecular models.

Analysis:

1. How many atoms are there in:

a) A hydrogen molecule? b) A chlorine molecule?

c) A hydrogen chloride molecule?

2. Are the hydrogen, chlorine and hydrogen chloride molecules identical? How do they differ?

Remark

Molecular models can be either of the type ball-and-stick models,or space-filling models.

Activity 2

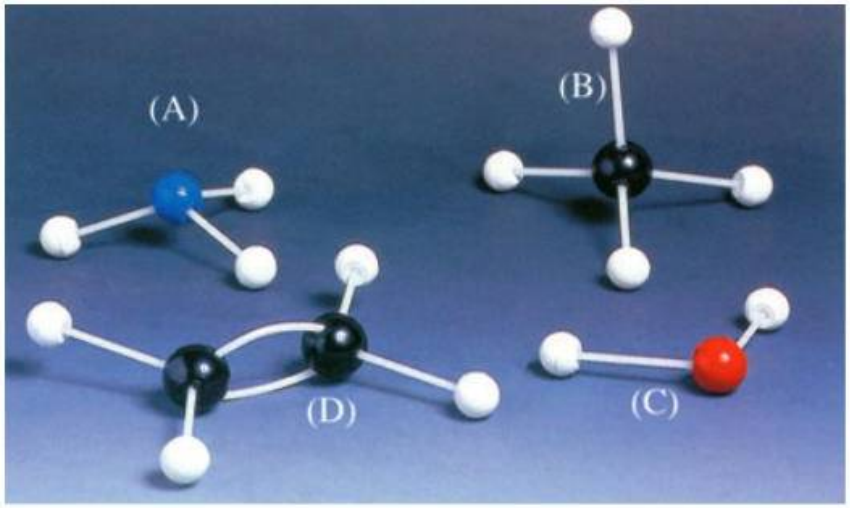
Consider the molecules shown in Fig. 47.

1. Copy the following table in your copybook and complete it.

Molecule contains	Hydrogen atom	Nitrogen atom	Oxygen atom	Carbon atom
Methane				
Water				
Ammonia				
Ethene				

2. Do the different molecules have the same composition?

3. Are the molecules of the different compounds the same?



Atom	Color
Carbon	Black
Hydrogen	White
Nitrogen	Blue
Oxygen	Red

Fig. 47 Molecular models of ammonia (A), methane (B), water (C) and ethene (D).

Conclusion

- Molecules are made up of the same or different atoms.
- All the molecules of a given molecular compound are identical.
- All the molecules of a given molecular element are identical.
- The molecules of one compound are different from those of any other molecular compound.
- A molecule of a molecular element is made up of two or more atoms of the same kind.

3 Ions

3.1. Definition of Ion

An atom or a group of combined atoms that has a charge is called an ion.

3.2. Formation of Ions

We can produce a charged entity, called ion, by taking a neutral atom and adding or removing one or more electrons.

Example 1:

A magnesium atom (Z = 12) has twelve electrons outside its nucleus. If the atom loses 2 electrons, it becomes an ion with a 2+ charge.

Charge of ion = total charge of protons + total charge of electrons

Charge of protons	12+
Charge of electrons	10-
Charge of ion	2+

We can represent this process as follows:

Magnesium atom ⇨ Magnesium ion + 2 electrons

A positive ion is called a cation. It is produced when one or more electrons are lost from a neutral atom.

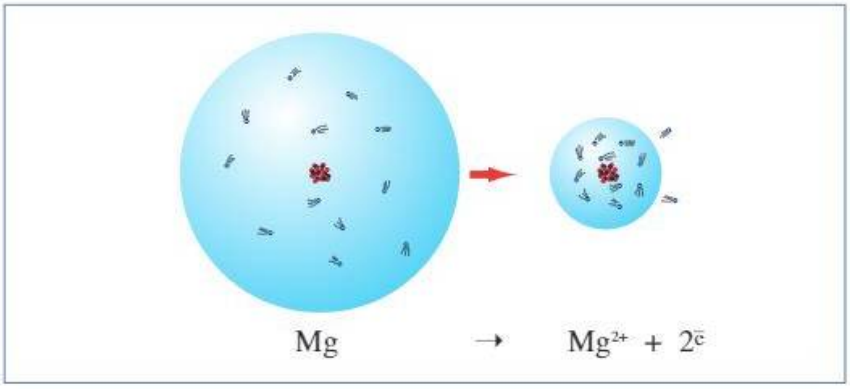


Fig. 48a A neutral magnesium atom loses 2 electrons, it becomes a magnesium ion with a 2+ charge.

Example 2:

A chlorine atom (Z = 17) has seventeen electrons outside its nucleus. If the atom gains one electron, it becomes an ion with a 1^- charge.

Charge of ion = total charge of protons + total charge of electrons

Charge of protons	17+
Charge of electrons	18-
Charge of ion	1-

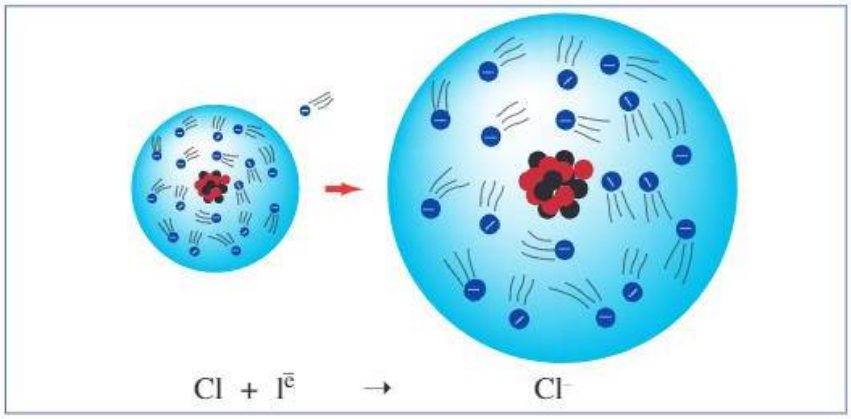


Fig. 48b A neutral chlorine atom gains an electron, it becomes a chloride ion with a 1- charge.

We can represent this process as follows:

Chlorine atom + 1 electron ⇨ Chloride ion

A negatively charged ion is called an anion. It is produced when one or more electrons are gained by a neutral atom.

3.3. Classification of Ions

Ions can be classified into monoatomic and polyatomic ions which themselves can be cations or anions.

Monoatomic Ions

Any ion formed when an atom gains or loses one or more electrons is known as monoatomic ion.

Polytomic Ions

Any ion that has two or more different atoms is called a polyatomic ion. Ions that have two atoms are called diatomic ions.

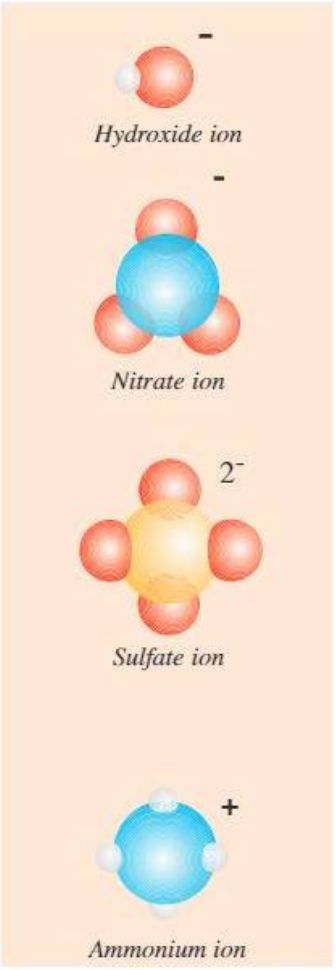


Fig. 48c Polyatomic ions.

Table of common monoatomic and polyatomic cations and anions.

Ions	Cations	Anions
Monoatomic ions	sodium, potassium, silver, calcium, magnesium, zinc, aluminum	chloride, bromide, iodide, sulfide
Polyatomic ions	ammonium	hydroxide, bicarbonate, nitrate, carbonate, sulfate, phosphate

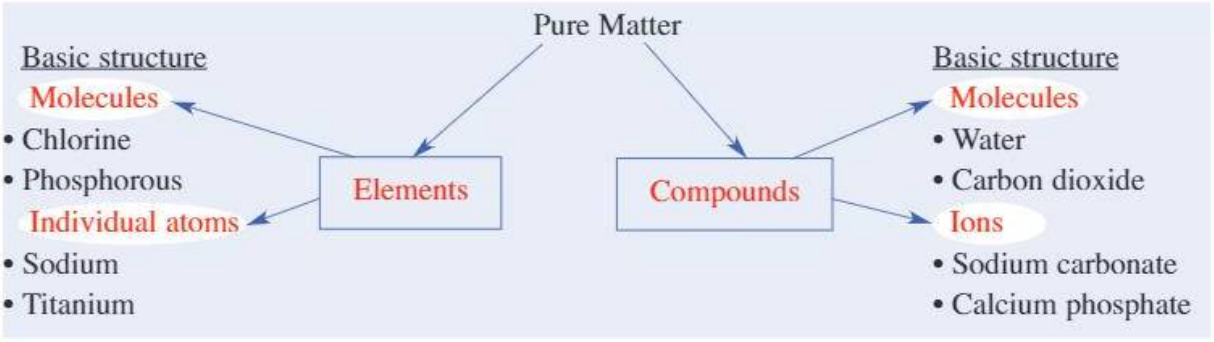
3.4. Basic Structure of Pure Matter

Pure matter is composed of either elements or compounds.

Elements exist in nature mostly as aggregates of individual atoms but may also be present as molecules.

Compounds can be composed of molecules or ions.

Ionic compounds are always composed of enough positive ions (cations) and negative ions (anions) to balance the charge.



a) Molecular Elements

Molecular elements whose state is diatomic are hydrogen, nitrogen, oxygen, fluorine, chlorine, bromine and iodine.

b) Atomic Elements

All metals are atomic elements. Only the noble gases such as: helium, neon, argon are monoatomic gases.

c) Ionic Compounds

Ionic compounds are solids at room temperature, have high melting points, are brittle, conduct electricity when molten or when dissolved in water (they are electrolytes). They are made up of oppositely charged ions.

d) Molecular Compounds

In general, molecular compounds have low melting points, and are not as hard as ionic compounds. Most molecular compounds are less soluble in water than ionic compounds. Molecular solutions do not conduct electricity. They are non-electrolytes. They are made up of molecules.

Activity 3

Using ball-and-stick models or space-filling models construct models of some familiar molecular compounds.

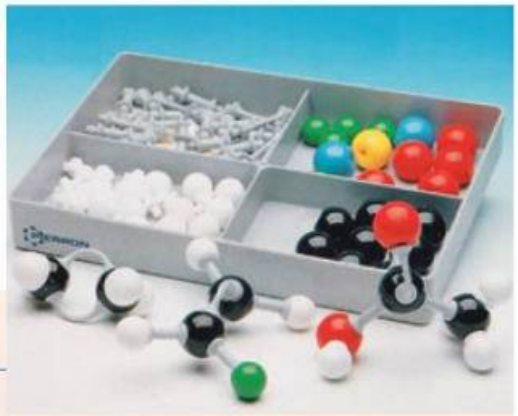
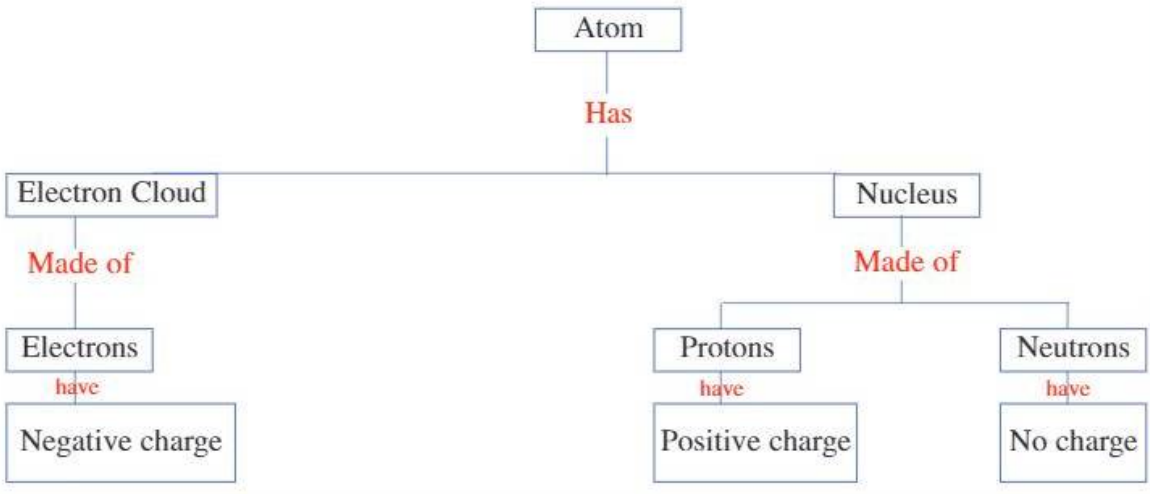


Fig. 49 Ball-and-stick, molecular models box.

Chapter Review

- The particles of matter can be made up of individual atoms, molecules or ions.
- The atom consists of a small massive region called the nucleus and a large region surrounding the nucleus called the electron cloud.
- The three fundamental particles of the atom are protons, neutrons and electrons.
- An atom is mainly made up of empty space.
- The atom is the smallest entity of an element and is made up of neutrons, and an equal number of electrons and protons.
- The number of protons in the nucleus of an atom is called atomic number and is denoted by the letter Z.
- A molecule is a neutral group of combined atoms that act as a unit.
- The ion, is an atom or group of combined atoms carrying a positive or negative charge.
- Positive ions are called cations and negative ions are called anions.

Concept Mapping



Insights

Looking for Quarks!

Protons, neutrons and electrons are the basic components of atoms.

Are these particles made up of even smaller particles?

Scientists hypothesize that electrons are not made up of any smaller particles.

Protons and neutrons, however, are made up of smaller particles called quarks.

A particular arrangement of three quarks held together with strong nuclear force produces a proton. Another arrangement of three quarks produces a neutron.

These subatomic particles hold the key to understanding nuclear forces.

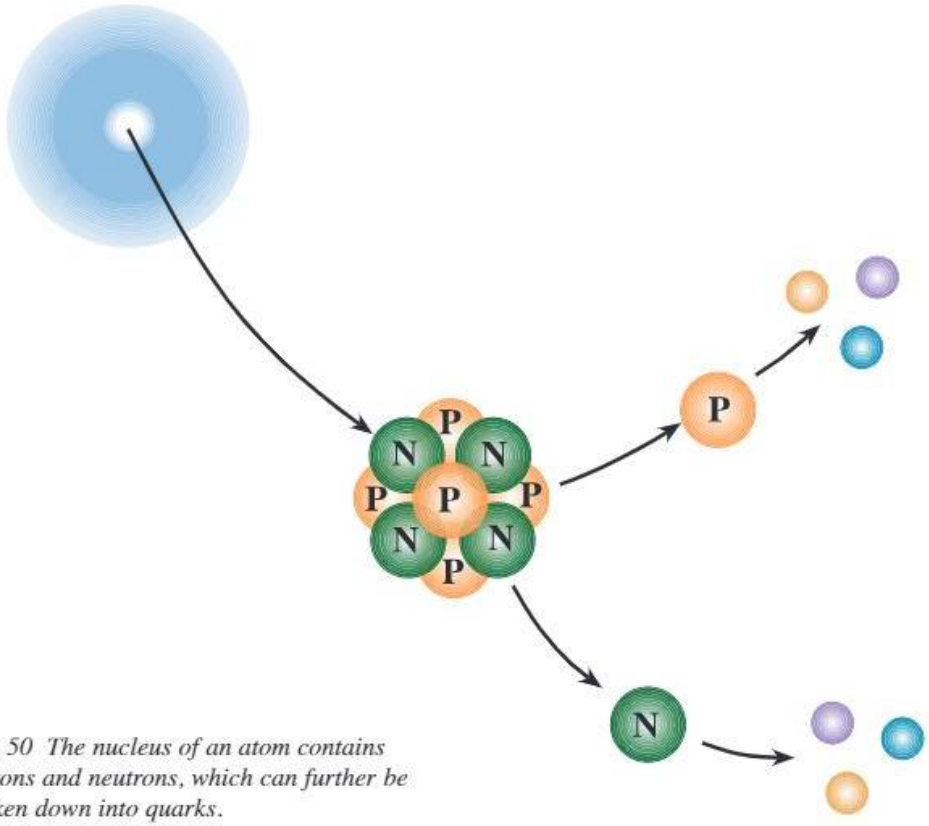


Fig. 50 The nucleus of an atom contains protons and neutrons, which can further be broken down into quarks.

Science and Society

1. Water Softening

Water containing calcium and magnesium ions is called hard water, and water that is mostly free of these ions is called soft water. Hard water is unsuitable for some household and industrial use because calcium and magnesium ions react with soap to form insoluble materials (scum).

Today, many homes and factories have devices that soften hard water by an ion-exchange process. In this process the calcium and magnesium ions are exchanged by sodium ions. Thus magnesium and calcium ions become caught in the device. The hard water ions are removed with the waste water from the exchanger.

Fig. 51 Hard water softener device.

2. Fertilizers

All living things need nutrients. Nutrients are best used when they are in the form of ions.

Nitrogen fertilizers contain ammonium ions, suflate and other ions. One of the main nutrients needed by plants is nitrogen. Plants can best use nitrogen in the form of nitrate ions directly, but ammonium ions must first be converted to nitrates by the action of soil bacteria.

Most farmers use fertilizers. When the amount of fertilizer applied is more than what the land can absorb, excess nitrate and other ions would seep into the underground water and pollute it.

Surface water will also be contaminated with nitrate and other ions. So, the use of fertilizers must be controlled.

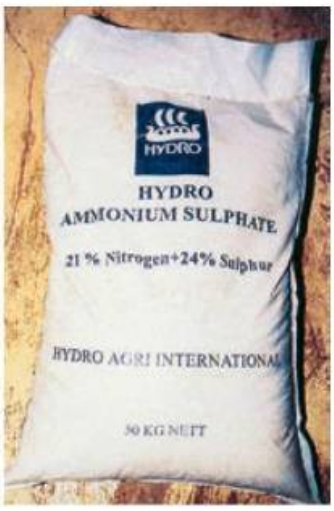


Fig. 52a Fertilizer containing ammonium sulfate.

Fig. 52b Farmers add fertilizers particularly to supply nitrogen (N) for plants.

Questions and Exercises

I- Write the word(s) that best complete(s) each statement:

1. Elements are composed of.....
2. Negatively charged subatomic particles are called.....
3. All atoms of the same element have the same atomic.....
4. The particle..... has a positive charge and a mass almost 1840 times the mass of an.....
5. Most of the mass of the atom is located in the.....
6. An atom that has lost an electron is..... charged and it is called.....
7. Bromine is a diatomic non-metal. It is a..... element.
8. Helium is a gas which exists as a (an)..... element, whereas oxygen gas is a..... element.
9. Molecular compounds are made up of ....., whereas ionic compounds are made up of..... and.....

II- Circle the letter of the answer that best completes each statement:

1. The center of the atom is called:
   a) electron
   b) neutron
   c) nucleus
   d) electron cloud
2. If an atom of an element contains 12 protons and 12 electrons, the atomic number of the element is:
   a) 12
   b) 24
   c) 0
   d) 21
3. Particles with opposite electrical charges:
   a) repel each other
   b) attract each other
   c) have no effect on each other
   d) form molecular compounds
4. Water is an example of:
   a) an ionic compound
   b) an element
   c) a molecular compound
   d) a non metal
5. A polyatomic ion always has:
   a) a negative charge
   b) a positive charge
   c) no electrical charge
   d) a positive or a negative charge.
6. An aluminum atom consists of 13 protons, 14 neutrons and 13 electrons. To become an aluminum cation (Al^{3+}) it has to lose:
   a) 3 neutrons
   b) 3 electrons
   c) 3 protons
   d) 2 electrons and 1 proton
7. Oxygen gas is a diatomic molecular element. The oxygen atom has 8 electrons, 8 protons and 8 neutrons. To become an anion it has to gain:
   a) 2 neutrons
   b) 2 electrons
   c) 2 protons
   d) 1 electron and 1 neutron

III- Write «T» if the statement is true and «F» if it is false. Change the underlined word to make the statement true.

1. An ion is a subatomic particle that has gained or lost an electron.
2. Protons and electrons make up the nucleus.
3. When you dissolve sugar in water, which is a molecular compound, ions are produced.
4. The region around the nucleus is called electron cloud. It contains neutrons.
5. The atom has an empty space structure.
6. A substance made up of two or more elements is a compound.
7. When an atom loses an electron it becomes a negative ion.

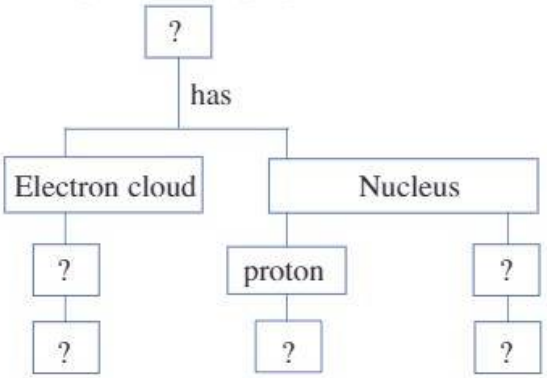
IV- Match each item in column (A) with the best answer in the right column (B).

Column (A)	**Column (B)**
1. Atomic number	a. positively charged particle in an atom.
2. Electron	b. formed when electrons are lost or gained.
3. Ion	c. subatomic particle with no charge.
4. Molecule	d. any ion that has two or more different elements.
5. Neutron	e. negatively charged particle in an electron cloud.
6. Proton	f. a neutral group of atoms that act as a unit.
7. Polyatomic ion	g. number of protons.
8. Nucleus	h. a small massive region found at the center of the atom.

V – Answer the following questions:

1. What are the fundamental subatomic particles that make up an atom? Make a list including their mass, compared to an electron, relative charge and location in the atom.

2. Below is a concept map. Only parts of the map are filled in. Copy the map and complete it with proper words.



3. In a neutral atom,
   a) which particles will always be present in equal numbers?
   b) what would happen to the charge if one of the electrons were removed from the atom?

4. Conduct a library research about the effect of the phosphate ion on aquatic life in lakes.

5. Conduct a library research about the advantages of the fluoride ion in the water you drink and the toothpaste you use.

6. List the names of three monoatomic ions, three polyatomic ions and two ions which are used in fertilizers.

CHAPTER *III*

Chemical Language

Chapter Overview

Chemists generally use the symbols for the elements that comprise the compound to write the chemical formula for that compound.

In the chemistry language, symbols are the letters of the chemical alphabet and chemical formulas are the words.

A few elements exist in nature in more than one elemental form; they are called allotropes. They have different chemical formulas.

Element	Ancient	Dalton's	Modern
Carbon			C
Copper			Cu
Gold			Au
Hydrogen			H
Iron			Fe
Mercury			Hg
Oxygen			O
Phosphorous			P
Silver			Ag
Sulfur			S
Zinc			Zn

Fig. 53 Modern chemists use shorthand representations of the names of elements, which can be understood by scientists around the world.

Chapter Contents

1 Symbols and Formulas

1.1. Chemical Symbols of Elements

The language of chemistry is based on a set of shorthand for the names of elements.

Chemists have special abbreviations for writing the names of the elements. These abbreviations, which are the shortened names for the elements, are called chemical symbols of the elements.

Chemical symbols are a universal language that chemists, all over the world, understand and use.

1.2. Writing Chemical Symbols of Elements

The chemical symbols of elements are always written in the same way. When writing chemical symbols of elements, the following rules apply:

a) Each chemical symbol consists of one or two letters, usually taken from the element's name.

b) The first letter is always capitalized, and the second letter is never capitalized.

Symbols of some elements.

For example,

Oxygen	O	Neon	Ne
Carbon	C	Silicon	Si

Sometimes, the two letters used are not the first two letters in the name. For example,

Zinc	Zn	Chlorine	Cl
Magnesium	Mg	Platinum	Pt

The symbols for some other elements are based on the original Latin or Greek name.

English name	Symbol	Original name
Gold	Au	Aurum
Sodium	Na	Natrium

Table 3.1 Some Common Elements

Element	Symbol
Aluminum	Al
Beryllium	Be
Boron	B
Bromine	Br
Calcium	Ca
Carbon	C
Chlorine	Cl
Fluorine	F
Helium	He
Hydrogen	H
Potassium	K

Element	Symbol
Iodine	I
Magnesium	Mg
Nitrogen	N
Oxygen	O
Phosphorous	P
Silicon	Si
Sulfur	S

Table 3.2 Elements with symbols from earlier names

Element	Symbol	Original Name
Copper	Cu	Cuprum
Gold	Au	Aurum
Iron	Fe	Ferrum
Lead	Pb	Plumbum
Mercury	Hg	Hydrargyrum
Potassium	K	Kalium
Silver	Ag	Argentum
Sodium	Na	Natrium
Tungsten	W	Wolfram

Remark

- Sometimes a formula represents a molecule of an element, not a compound.
- The symbol of the element oxygen is O, but oxygen occurs naturally as a molecule containing two atoms of oxygen joined together. So the formula for a molecule of oxygen is O_2.

1.3. Chemical Formulas

A chemical formula is a shorthand way of writing the name for a compound. It specifies the composition of a chemical substance.

N_2

Is the formula for a molecule of the element Nitrogen

CO_2

Is the formula for a molecule of the compound carbon dioxide

1.4. Writing Formulas of Compounds

When writing a chemical formula, you use the symbol of each element in the compound. You also use small numbers called subscripts.

Glossary

Subscript is a number placed to the lower right of a chemical symbol. It gives the number of atoms of the element in the compound.

Following are some general principles for writing formulas:

- Each atom present is represented by its chemical symbol.
- The number of each type of atoms is indicated by a subscript.
- When only one atom of a given type is present, the subscript **1** is not written.
- In ionic compounds, the electrical charges of cations and anions must balance.

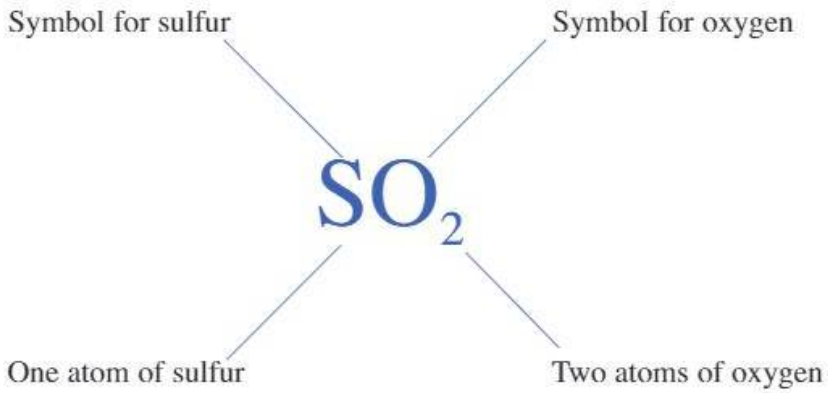
An ionic compound is electrically neutral.

Example 1:

Write the formula for each of the following compounds, listing the elements in the order given.

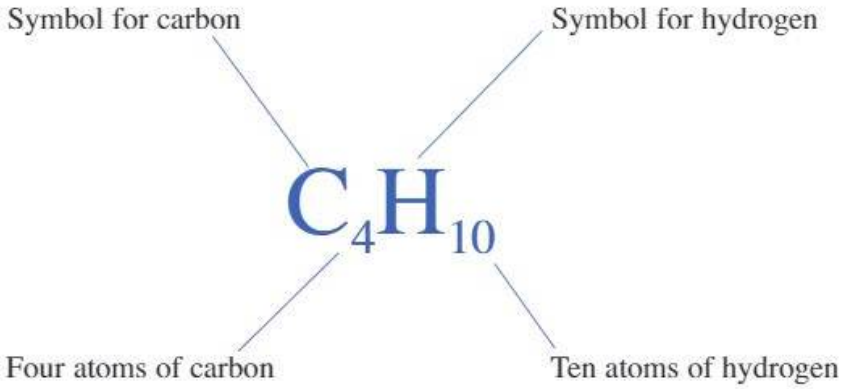
a) Each molecule of a compound that has been implicated in the formation of acid rain contains one atom of sulfur and two atoms of oxygen.

Solution



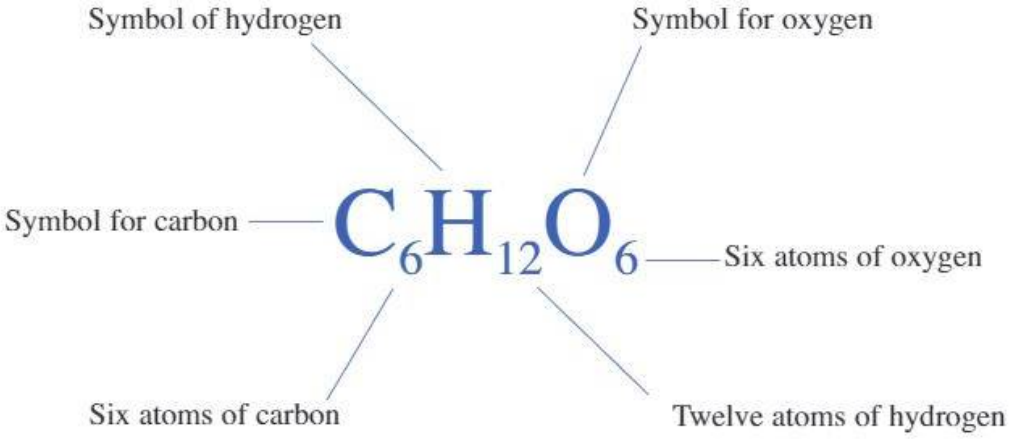
b) Each molecule of butane gas, used as fuel, contains four atoms of carbon and 10 atoms of hydrogen.

Solution



c) Each molecule of glucose, a type of sugar, contains six atoms of carbon, twelve atoms of hydrogen and six atoms of oxygen.

Solution



d) Each molecule of liquid ammonia, which is used as fertilizer, contains one nitrogen atom and three hydrogen atoms. **Copy this schematic diagram on your copybook and write in the boxes the proper terms.**

Table 3.3 Some common cations and anions

Common Cations (monoatomic)

Name of ion	Symbol
Hydrogen ion	H^+
Potassium ion	K^+
Silver ion	Ag^+
Sodium ion	Na^+
Calcium ion	Ca^{2+}
Magnesium ion	Mg^{2+}
Zinc ion	Zn^{2+}
Cupric ion	Cu^{2+}
Ferrous ion	Fe^{2+}
Aluminum ion	Al^{3+}

Common Anions (monoatomic)

Name of ion	Symbol
Bromide ion	Br^-
Chloride ion	Cl^-
Iodide ion	I^-
Sulfide ion	S^{2-}

Polyatomic cation

Name of ion	Formula
Ammonium ion	NH_4^+

Polyatomic amions

Name of ion	Formula
Hydroxide	HO^-
Hypochlorite	ClO^-
Hydrogen carbonate (bicarbonate)	HCO_3^-
Nitrate	NO_3^-
Sulfate	SO_4^{2-}
Carbonate	CO_3^{2-}
Phosphate	PO_4^{3-}

Writing the formula of ionic compound using the "crisscross" method.

Example 2

The pairs of ions contained in several ionic compounds are listed below. Give the formula for each compound.

a) Na^+ and Cl^-
b) Ca^{2+} and NO_3^-
c) Al^{3+} and SO_4^{2-}

Remark

- For polyatomic ions the charges are written to the right of the formula of the ion. The charge applies to the ion as a whole and not to any individual element.
- When writing formula of ionic compounds, write the cation first.
- A simple cation has the same name as its parent element.

Solution

a) Formula of the compound containing the pair of Na^+ and Cl^- ions.

The steps involved in the crisscross method are:

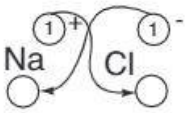
Step 1: Write the symbol (formula) of the cation followed by the symbol (formula) of the anion.

Na^+ Cl^-

Remark

Use the least common multiple (the smallest whole-number ratio of ions). The correct formula of the compound obtained from Ba^{2+} and S^{2-} is BaS not Ba_2S_2.

Step 2: Make the subscript for one ion equal to the number of charges on the other.



Step 3: Write the subscripts. The formula of the compound is NaCl.

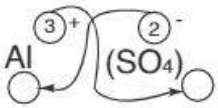
b) Formula of the compound containing the pair of the ions Ca^{2+} and NO_3^- ions.

Apply the above given steps.

The formula of the compound is $Ca(NO_3)_2$

c) Formula of the compound containing the pair of ions Al^{3+} and SO_4^{2-}

Apply the above given steps.



The formula of the compound is $Al_2(SO_4)_3$

Fig. 54 Allotropes of phosphorous.

- *White phosphorous is used in napalm, a really nasty chemical weapon.*
- *Red phosphorus is the element usually found in the laboratory.*

2 Allotropes

- A few elements notably oxygen, phosphorous, sulfur and carbon, exist in nature as allotropes.

2.1. Definition

Allotropes are different molecular forms of an element in the same physical state that exhibit different chemical and physical properties.

2.2. Allotropic Forms of Carbon

Carbon has several interesting allotropes in the solid state. One allotrope is graphite the other is called diamond.

The physical appearance and the properties are determined only by the manner in which the carbon atoms are linked together.

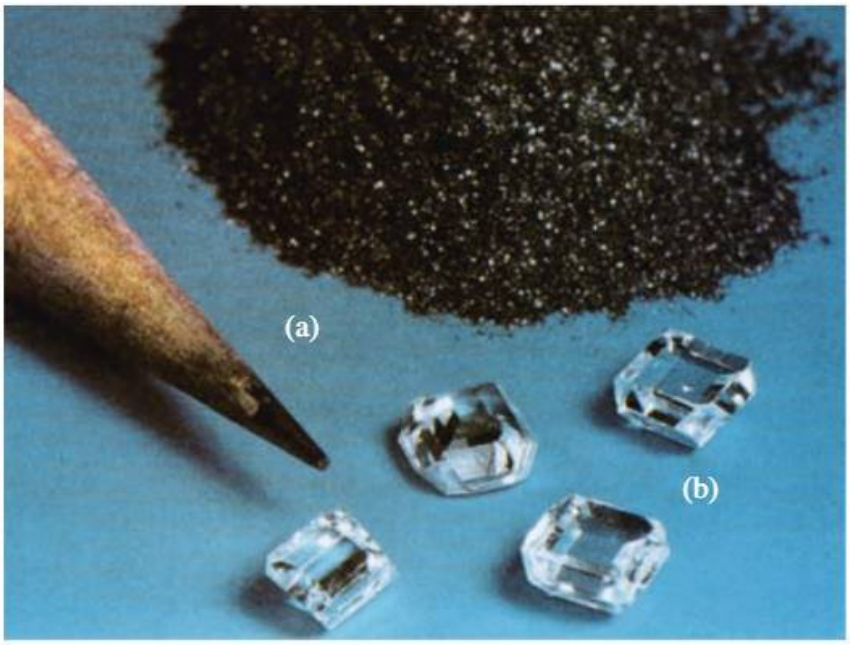


Fig. 55 The two allotropes of carbon: a)Graphite b) Diamond

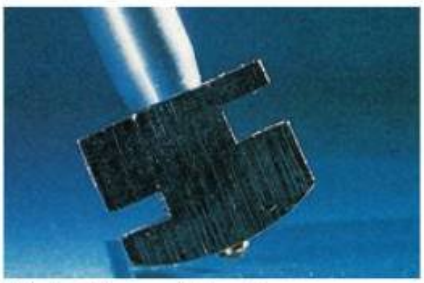


Fig. 56 Diamond-tipped cutters are used to etch hard surfaces.

Fig. 57 Graphite, a slippery black material used in lubricants and "lead" pencils.

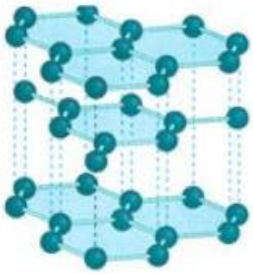


Fig. 59 The carbon atoms in graphite are bound in layers.

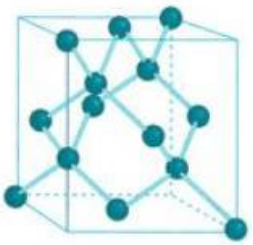


Fig. 58 The carbon atoms in diamond are interconected in a network-tetrahedral arrangement.

Activity

Observe a piece of graphite and a piece of artificial diamond (if available). List the differences between the two. Try to write with the piece of graphite and with the piece of diamond to demonstrate the differences between them.

Chapter Review

- Chemical symbols are the shortened names for the elements.
- The symbol of an element consists of one or two letters, usually taken from the element's name.
- The first letter of the symbol is always capitalized, the second is not.
- A chemical formula is a shorthand way for writing the name of a compound. It specifies the composition of a chemical substance.
- The formula of a molecular compound shows the kind and the number of atoms of each element forming the compound.
- In the formula of an ionic compound, electrical charges of cations and anions must balance. An ionic compound is electrically neutral.
- Allotropes are different molecular forms of an element in the same physical state that exhibit different chemical and physical properties.

Insights

1. Fullerenes – Buckyballs

The most recently discovered carbon allotrope, consisting of 60 carbon atoms, is called fullerene C_{60}. This allotrope looks like a globe-shaped, geodesic dome. Ordinary soot has been found to contain small, variable amount of other molecular forms of carbon designated as C_{70} .

Many new uses of this third allotrope were thought possible. It has been suggested that C_{60} might be used as a lubricant.

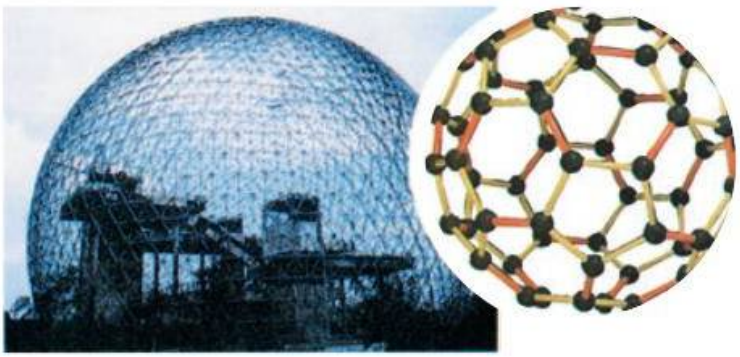


Fig. 60 The Geodesic dome is designed by the engineer Buckminster Fuller. For this reason it is called "buckyball".

2. Ozone Allotrope of Oxygen

Ozone (O_3) is an allotropic form of oxygen gas. It can be formed by any high voltage discharge.

You can smell ozone around photocopy machines. Small amounts are also formed in TV sets. Because ozone is harmful, it is advisable that you do not sit close to your TV set.

Although ozone is a toxic light blue gas, it plays a central role in two processes that affect our lives. Near the surface of earth, ozone promotes the formation of smog, which is harmful to all living things. Ozone is also present in the upper layers of the atmosphere at a height of 10-45 Km above the surface of the earth. There it absorbs much of the harmful high-energy solar radiation and thus protects life beneath.

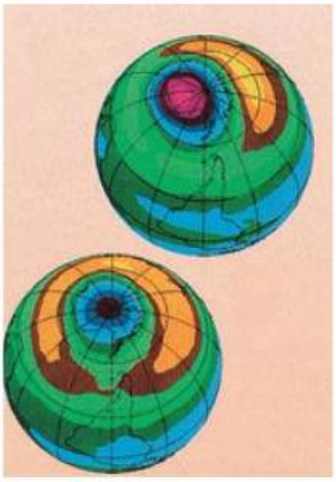


Fig. 61 The lowest levels of ozone shown in pink are located over the polar regions.

Science and Society

High Temperature and Pressure Turn

Black Graphite into Sparkling Diamonds

The element carbon exists in several allotropic forms, two of which are graphite and diamond. Under ordinary condition, graphite is the more stable form of the element; that is why this form of the element is more abundant and inexpensive.

Diamonds relatively are rare and expensive, so a process that converts graphite into diamond is quite profitable.

In 1995, scientists developed a process to make commercial grade diamonds at a temperature of 2000-2500°C and a pressure near 125,000 atmospheres. Today, more than 40% of diamonds are synthetic.

Glossary

Smog: Air pollution over urban areas.
Combination of the words smoke and fog.

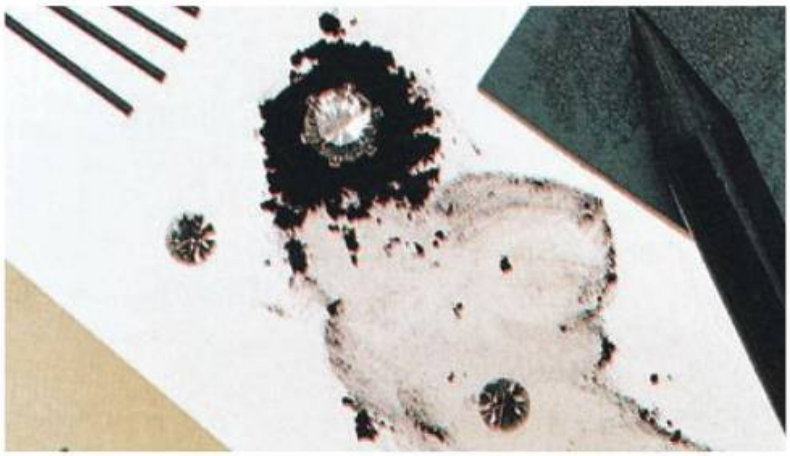


Fig. 62 Process to convert graphite into diamond.

Questions and Exercises

I- Write the word(s) that best complete(s) each statement.

1. A..... shows how many atoms of an element are contained in one molecule of a compound.

2. Subscript is a number placed to the lower..... of the..... in a formula.

3. In an ionic compound electrically charged cations must..... the anions.

4. Allotropes are..... molecular forms of an..... in the same.....

II- Circle the letter of the answer that best completes each statement.

1. An example of a polyatomic ion is:

a) SO_4^{2-}

b) Ca^{2+}

c) O_2

d) NaCl

2. The formula of the compound ammonium nitrate consists of the following pairs of ions:

a) NH_4^+ and Cl^-

b) NH_4^+ and HO^-

c) Ca^{2+} and NO_3^-

d) NH_4^+ and NO_3^-

3. The possible formula of calcium phosphate consisting of Ca^{2+} ions and PO_4^{3-} ions is:

a) Ca PO_4

b) $Ca_2(PO_4)_3$

c) $Ca_3(PO_4)_2$

d) Ca_3PO_4

4. A household cleaning agent contains the compound sodium hypochlorite which consists of sodium ions and hypochlorite ions. The formula of the compound is:

a) NaClO

b) SHClO

c) NaCl

d) NaHCl

5. The pair of ions contained in a compound used as a fertilizer are ammonium and phosphate ions. The possible formula of the compound is:

a) NH_4PO_4

b) $NH_4(PO_4)_2$

c) $(NH_4)_3PO_4$

d) $(NH_3)_4PO_4$

III- Answer the following questions:

1. Write the formula of each of the following compounds, listing the elements in the given order.

a) Each molecule of a compound that has been implicated in the formation of acid rain contains one atom of nitrogen and two oxygen atoms.

b) Each molecule of nitric acid contains one

hydrogen atom, one nitrogen atom, and three oxygen atoms.

c) Baking soda contains one sodium atom, one hydrogen atom, one carbon atom and three oxygen atoms.

2. Write the formulas of the following ionic compounds: calcium sulfide, aluminum chloride, potassium bicarbonate, sodium sulfate.

3. The label on a package of greenhouse fertilizer lists potassium carbonate as one ingredient. What is the formula of potassium carbonate?

4. The ionic compound calcium chloride is used as a drying agent, and in manufacturing glue and concrete. Write its formula.

5. Conduct a library research about the allotropes of phosphorous and their uses.

6. Conduct a library research about Alchemy in the medieval period.

7. Write the following formulas in the correct form: AlS, KCl_2, $CaNO_3$.

8. A molecule of sugar (glucose) contains 6 carbon atoms, 12 hydrogen atoms and 6 oxygen atoms.

a) Write the molecular formula of glucose.

b) What number of oxygen atoms is there in 5 molecules of glucose?

IV- Copy the following table in your copybook and complete it.

		Anions				
		Cl^-	NO_3^-	O^{2-}	SO_4^{2-}	CO_3^{2-}
CATIONS	Na^+					
	Ca^{2+}				$CaSO_4$	
	Fe^{2+}					
	Ag^+					Ag_2CO_3
	Al^{3+}					

a) Which type of ion positive or negative, did you write first in these chemical formulas?

b) Give the name of each compound.

Unit three

CHEMICAL REACTIONS

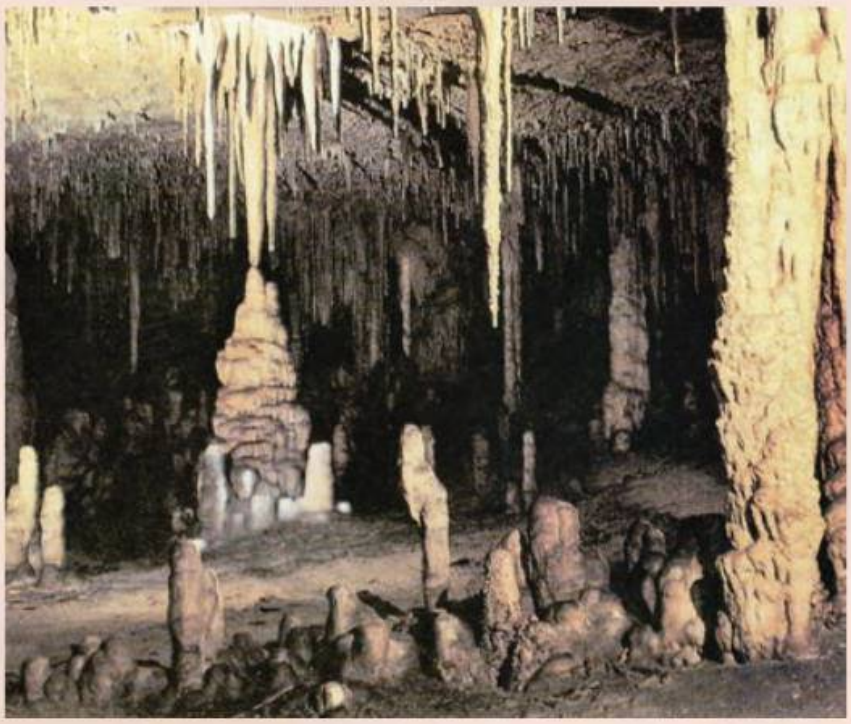


Fig. 1 Ground water seeps through cracks reacting with limestone giving rise to the formation of stalactites and stalagmites.

Unit Overview

Chemical reactions play an enormous role in our life. Chemical reactions make it possible for our body to use the air we breathe and the food we eat.

The raw materials found in nature can be converted into chemicals which are then used to make products we buy. Most of the products we use are made from raw materials such as petroleum, natural gas and minerals. Some chemicals are used in the laboratories to conduct experiments and know the results of many reactions.

The nature of the chemical reactions, their classification, as well as the factors that influence the rates of the chemical reactions help us understand the world around us.

Contents

Fig. 3 A household product containing sodium hydroxide and a small quantity of aluminum flakes is used as a drain cleaner.

Fig. 2 Hydrogen-filled balloons can even ignite from a distance and explode. Be careful! The reaction is spontaneous.

Fig. 4 When Vitamin C tablet is added to water, new substances are formed.

CHAPTER *I*

Chemical Equations and Reactions

Chapter Overview

Many familiar processes in nature and in everyday life involve chemical reactions. When a chemical reaction takes place, there is always a change in the properties and energy content of substances involved in the reaction.

Chemical reactions are represented by chemical equations. Substances involved in the reaction are represented by their symbols or formulas in the equation which is written in accordance with the law of conservation of mass.

Fig. 5 The colors produced in fireworks displays are due to chemical reactions.

Chapter Contents

1 Chemical Reactions

1.1. Recognizing Chemical Reactions

When a substance undergoes a chemical change, it takes part in a chemical reaction. After it reacts, it no longer has the same chemical identity.

Fig. 6 Magnesium burns with a brilliant flame. Magnesium oxide (white powder) is the product of the reaction.

Activity 1a

Materials:

- Magnesium ribbon
- Watch glass
- Metallic tongs
- Test tubes (a), (b)
- Spatula
- Hydrochloric acid (1 M)
- Match

Procedure:

- Using metallic tongs, hold a small piece of magnesium ribbon over the watch glass.
- Carefully, ignite the extremity of the magnesium ribbon and collect the material formed on the watch glass.

Analysis:

1. Is a new substance produced during the process of burning of magnesium?
2. What type of change did magnesium undergo?
3. With what substance did magnesium combine?

Activity 1b

Procedure:

- Into test tube (a), containing a small piece of magnesium (1 cm), pour some hydrochloric acid to fill 1/3 of the tube.
- Into test tube (b), 1/3 filled with hydrochloric acid, put a small quantity of the product formed in Activity 1-a.

Safety

Wear eye goggles to protect your eyes.

Analysis:

1. Describe what happens in test tube (a)? In test tube (b)?
2. Does magnesium and the product formed behave in the same way with hydrochloric acid?
3. Is the chemical identity of magnesium the same, before and after the combustion?

Conclusion

- The process by which a chemical change takes place is called a chemical reaction.
- New substances are formed as a result of a chemical reaction.
- The chemical identities of the substances entering into a reaction are not the same as those which result from it.

1.2. Chemical Reactions in Everyday Life

Fig. 7 Do the cooked eggs look, feel and taste different from raw eggs?

Fig. 8 When a match burns, does it undergo a chemical reaction? Does it produce heat?

Fig. 9 What makes the unbaked dough rise when cooked?

Fig. 11 The power generated by the battery is due to a chemical reaction.

Fig. 10 All of the items shown here, and many other plastic housewares are manufactured from the raw material, petroleum.

Conclusion

When a chemical reaction takes place, there is always a change in the properties and in the energy content of substances involved in the chemical reaction.

1.3. Chemical Equations

In any chemical reaction, certain substances, called reactants, are present at the start of the reaction, and certain substances, called products, formed by the change, are present at the end of the reaction.

Fig. 12 Formation of green precipitate. Ferrous hydroxide.

Activity 2

Materials:

- Ferrous nitrate solution (1M)
- Potassium hydroxide solution (1M)
- 2 Beakers (100 mL)

Procedure:

- Pour about 10 mL of potassium hydroxide solution, little-by-little, into a beaker containing 50 mL ferrous nitrate solution.

Analysis:

Knowing that the products of this reaction are potassium nitrate and ferrous hydroxide, describe, what happens.

Glossary

Reactant: A substance that enters a chemical reaction.

Product: A substance that is produced by chemical reaction.

a) Word Equation

A word equation represents the names of the reactants and the products.

The word equation of the reaction in activity-2 can be written as follows:

Potassium hydroxide + Iron(11) nitrate → Potassium nitrate + Iron(11) hydroxide

- The plus (+) sign means reacts with.
- The arrow (→) means yields, or produces, or gives.
- The arrow indicates the direction of the reaction from the reactants (substances on the left-hand side) to the products (substances on the right-hand side).

In a chemical reaction, atoms of the reactants are rearranged to produce the products.

Reactants → Products

b) Unbalanced Chemical Equation

The unbalanced chemical equation is a description of a chemical reaction using symbols and formulas for the reactants and the products.

The unbalanced equation of the previous reaction is written as:

$Fe(NO_3)_{2\,(aq)} + KOH_{\,(aq)} \rightarrow Fe(OH)_{2\,(s)} + KNO_{3\,(aq)}$

The unbalanced chemical equation is read in exactly the same way as the word equation – ferrous nitrate reacts with potassium hydroxide to produce ferrous hydroxide and potassium nitrate.

Glossary

A coefficient is a number that appears in front of symbol or formula in a chemical equation.

c) Chemical Equation

A chemical equation is a shorthand expression for a chemical reaction.

The chemical equation for a reaction provides us with two important types of information:

i – the identities of the reactants and products.

ii – the relative numbers (coefficients) of each.

The chemical equation of the previous reaction is written as:

$Fe(NO_3)_{2\,(aq)} + 2KOH_{\,(aq)} \rightarrow Fe(OH)_{2\,(s)} + 2KNO_{3\,(aq)}$

Remark

- The term chemical equation stands for balanced chemical equation.
- When no coefficient is written, it is understood to be 1.

Example 1

For each of the following chemical reactions write:

1. The word equation
2. The unbalanced chemical equation
3. The chemical equation

a) Butane gas is a good fuel for a portable burner. Butane burns with oxygen in the air to produce carbon dioxide and water vapor.

b) The most common example of corrosion is rust. Rust is formed when iron combines with oxygen in the humid air to form iron (III) oxide.

c) One of the common household uses for H_2O_2 is as mild antiseptic. It kills bacteria. The fizzing that occurs when H_2O_2 is poured over a cut is caused by the decomposition of H_2O_2 into water and oxygen gas. This decomposition is activated by the presence of an enzyme found in blood.

d) Vinegar (acetic acid) and baking soda (sodium bicarbonate) react vigorously, forming a bubbly product. The bubbles produced contain carbon dioxide. Other products of the reaction are sodium acetate and water.

e) Hard water contains calcium and magnesium ions. When sodium carbonate is added to hard water, water is softened. For example, magnesim chloride reacts with sodium carbonate to form sodium chloride and magnesium carbonate, a white precipitate which can be removed from hard water.

Fig. 13a The combustion of butane is highly exothermic.

Fig. 13b Hydrogen peroxide poured over a cut.

Solution

1 – Word Equation

a) Butane + Oxygen → Carbon dioxide + Water vapor

b) Iron + Oxygen → Iron (III) oxide

c) Hydrogen peroxide → Water + Oxygen gas

d) Acetic acid + Sodium bicarbonate → Sodium acetate + Carbon dioxide + Water

e) Magnesium chloride + Sodium carbonate → Magnesium carbonate + Sodium chloride

Remark

Common symbols in chemical equations:
The physical state of each substance in an equation is indicated by the following designations:
- (s) for solid
- (l) for liquid
- (g) for gas
- (aq) for ions in aqueous solution.

2 – Unbalanced Chemical Equation

The unbalanced chemical equation for each of the above mentioned chemical reactions is written as follows:

a) $C_4H_{10\,(g)} + O_{2\,(g)} \rightarrow CO_{2\,(g)} + H_2O_{(g)}$

b) $Fe_{(s)} + O_{2\,(g)} \rightarrow Fe_2O_{3\,(s)}$

c) $H_2O_{2\,(aq)} \rightarrow H_2O_{(l)} + O_{2\,(g)}$

d) $HC_2H_3O_{2\,(aq)} + NaHCO_{3\,(aq)} \rightarrow NaC_2H_3O_{2\,(aq)} + CO_{2\,(g)} + H_2O_{(l)}$

e) $MgCl_{2\,(aq)} + Na_2CO_{3\,(aq)} \rightarrow MgCO_{3\,(s)} + NaCl_{(aq)}$

Fig. 14 Bubbles are formed when vinegar and baking soda react.

3 – Chemical Equation

The chemical equation for each of the above mentioned reactions is written as:

a) $2C_4H_{10\,(g)} + 13O_{2\,(g)} \rightarrow 8CO_{2\,(g)} + 10H_2O_{(g)}$

b) $4Fe_{\,(s)} + 3O_{2\,(g)} \rightarrow 2Fe_2O_{3\,(s)}$

c) $2H_2O_{2\,(aq)} \rightarrow 2H_2O_{(l)} + O_{2\,(g)}$

d) $HC_2H_3O_{2\,(aq)} + NaHCO_{3\,(aq)} \rightarrow NaC_2H_3O_{2\,(aq)} + CO_{2\,(g)} + H_2O_{(l)}$

e) $MgCl_{2\,(aq)} + Na_2CO_{3\,(aq)} \rightarrow MgCO_{3\,(s)} + 2NaCl_2$

We can conclude from the previous reactions that certain tendencies in reactants drive them to form products. That is, there are several types of changes that pull reactants toward products – changes that tend to make reactions go in the direction of the arrow. The most common of these driving forces for reactions that take place between ions combining in aqueous solutions, and between metals and non-metals, are:

i – Formation of precipitate

ii – Formation of water

iii – Formation of gas

iv – Transfer of electrons

2 Balancing Chemical Equations

In a chemical reaction, atoms are neither created nor destroyed.

A chemical equation must show that atoms are conserved in a chemical reaction. The number of atoms of each element must be the same on both sides of the equation. The equation thus obtained is called a balanced chemical equation.

A – Process of balancing a chemical equation:

The process of balancing a chemical equation consists of several steps:

1. Write the word equation for the reaction.
2. Write the symbols and formulas for reactants and products.
3. Count the number of atoms of each element on each side of the arrow.
4. Balance the equation using coefficients. Put a coefficient in front of a symbol or formula, so that the same number of each type of atom appears on both reactant side and product side. Continue this procedure until you have balanced all the atoms.
5. Check to see that the coefficients used are the smallest whole numbers that give the balanced equation.

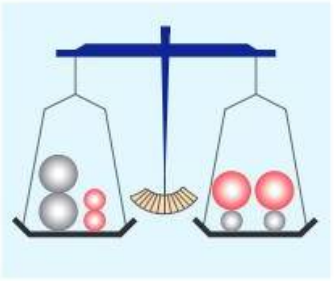


Fig. 15 Balancing of atoms. Law of conservation of mass.

$2Mg + O_2 \rightarrow 2MgO$

Example 2

The combustion reaction of methane with oxygen produces carbon dioxide and water.

Balance the chemical equation of the reaction.

Solution:

step 1: methane + oxygen → carbon dioxide + water

step 2: $CH_4 + O_2 \rightarrow CO_2 + H_2O$

step 3: Count the number of atoms of each element on each side of the arrow

step 4: $CH_4 + 2O_2 \rightarrow CO_2 + 2H_2O$

step 5: There are 1C, 4H and 4O atoms on both sides of the arrow. The coefficients used are the smallest whole numbers that give the balanced equation.

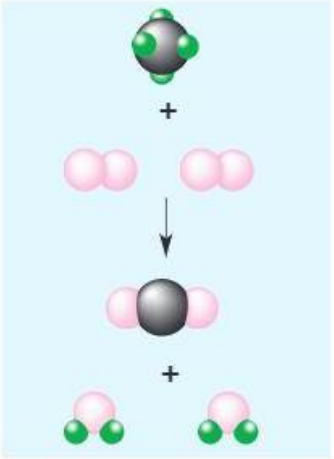


Fig. 16 The molecular models illustrate that the number of atoms of each element on both sides of the arrow are equal as required by the law of conservation of mass.

B – Balancing Equations Using Models

Molecular models can be used to demonstrate:

1- the rearrangement of atoms in a chemical reaction.

2- the law of conservation of mass.

Activity 3

Materials:

• Space-filling molecular models • Ball-and-stick molecular models

Procedure:

- Make models to represent the reactants.
- Make models to represent the products.
- Make sure you have the same number of each type of atom on each side of the equation.

A properly balanced equation has the same number of each type of atoms in the reactants and the products.

The reaction of hydrogen and oxygen, represented by ball-and-stick molecular models, is given in Fig. 17a.

The decomposition reaction of hydrogen peroxide, portrayed by space-filling molecular models, is given in Fig. 17b.

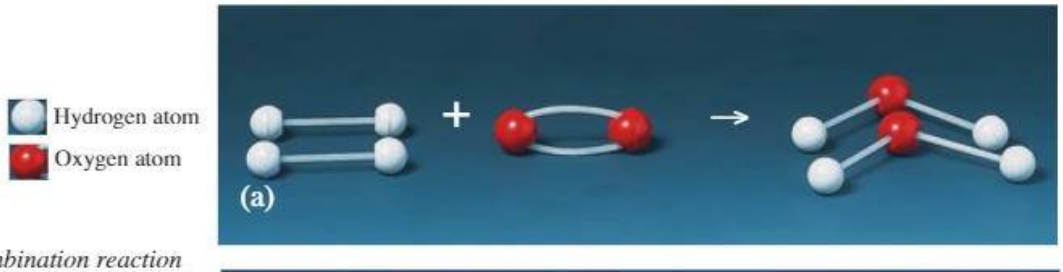


Fig. 17a Combination reaction of hydrogen and oxygen.

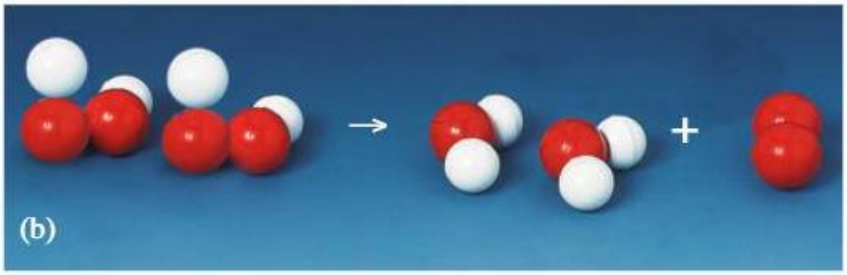


Fig. 17b Decomposition reaction of hydrogen peroxide.

Chapter Review

- The process by which a chemical change takes place is called a chemical reaction.
- New substances are formed in a chemical reaction.
- There is always a change in the properties and in the energy of the substances involved in a chemical reaction.
- A substance that enters into a chemical reaction is called a reactant.
- A substance that is produced by a chemical reaction is called a product.
- A word equation gives the names of the reactants and the products.
- An unbalanced chemical equation describes the chemical reaction using symbols and formulas.
- A chemical equation is a shorthand expression of a chemical reaction.
- The most common driving forces for chemical reactions to take place are:

  formation of precipitate (solid), formation of water, formation of gas and transfer of electrons.
- In a chemical reaction atoms are neither created nor destroyed. They are rearranged.
- To balance a chemical equation:
  - First identify the reactants and products and write their symbols and formulas.
  - Next write the unbalanced equation.
  - Then balance by trial and error, starting with the most complicated molecules.
  - Finally, check to be sure the equation is balanced with the smallest whole numbers possible.

Insights

Caution! It is advisable not to refreeze a thawing food.

Fig. 18 Freezing is one way of preserving food.

1. FREEZING - Food Processing and Preservation

Freezing is one of many processes involved in preserving food against microbes and other agents that spoiled food in order to permit its future consumption.

Freezing preserves food by preventing microbes from multiplying. Because the process does not kill all types of bacteria, those that survive reanimate in thawing food and often grow more rapidly than before freezing.

In thawing, food may undergo some changes. Refreezing does not retain the appearance, texture, flavor and nutritional value of foods, and is not recommended.

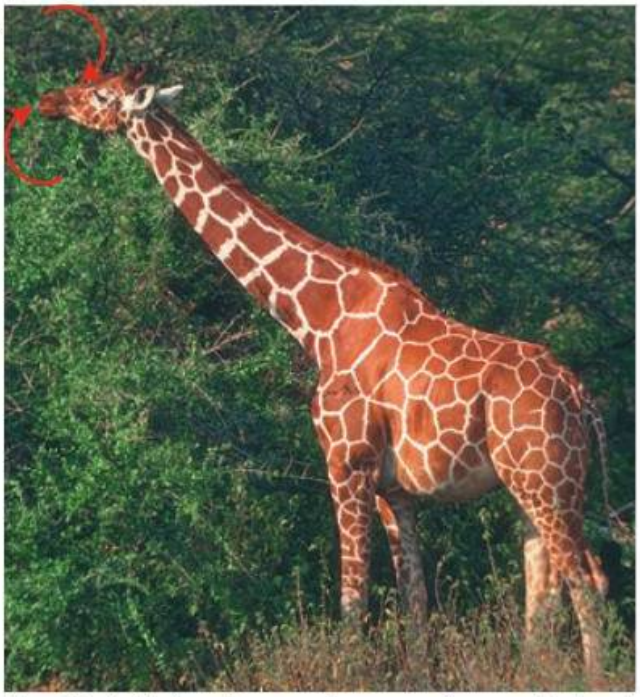


Fig. 19 In birds and mammals, energy from respiration is also used to maintain a constant body temperature.

2. RESPIRATION

- Respiration is an important process in all living things. During respiration, oxygen reacts with glucose to release energy. The energy released is used by the organism to carry out life activities. Respiration takes place inside body cells. As the hydrogen and carbon in foods are oxidized, carbon dioxide, water and energy are produced.

Glucose + Oxygen → Carbon dioxide + Water + Energy

Science and Society

1. Chemicals Help to Put out Fires

Fig. 21 Fire extinguishers like this one are filled with compressed carbon dioxide.

A fire extinguisher is a portable appliance designed to provide water and other agents to extinguish small fires.

Soda-acid type fire extinguishers contain sodium bicarbonate and sulfuric acid, which, when brought into contact with each other, react and produce sodium sulfate, water and carbon dioxide, according to the following equation:

$$H_2SO_{4\,(l)} + 2NaHCO_{3\,(aq)} \rightarrow Na_2SO_{4\,(aq)} + H_2O_{(l)} + CO_{2\,(g)}$$

As carbon dioxide is released from a fire extinguisher, it is a cool, dense gas. Being cool, CO_2 decreases the rate of burning, and, as a dense gas, it displaces air, which deprives the fire from the supply of oxygen.

2. The Chemistry of Safety Matches

The head of wooden or paperboard sticks of safety matches contains sulfur or diantimony trisulfide, as the combustible material, and potassium chlorate as the oxidizing agent, with ground glass, glue and paraffin underneath.

The striking surface is a layer of red phosphorous, powdered glass and glue.

The friction of the match on the striking surface changes red phosphorous to white phosphorous.

$$P\,(red) + heat \rightarrow P\,(white)$$

A small amount of white phosphorous is formed; it ignites spontaneously in air and gives off enough heat to ignite the match's head.

$$4P\,(white)_{(s)} + 5O_{2\,(g)} \rightarrow P_4O_{10\,(s)} + heat$$

Fig. 20 Wooden and paperboard safety matches.

Safety

Close the box before striking.

Questions and Exercises

I – Write the word(s) that best complete(s) each statement.

1. The substance(s) to the left of the arrow in a chemical equation is (are) called ..... .
2. The arrow in a chemical equation means ..... .
3. The number of atoms of each element on both sides of a chemical equation must always be ..... .
4. In a chemical reaction ..... are neither created nor destroyed, they are ..... .

II – Write "T" if the statement is true, and "F" if the statement is false, then change the underlined word(s), to make the statement true.

1. The substance(s) formed as a result of a chemical reaction (is) are called reactant(s).
2. A chemical equation uses symbols and formulas to represent a reaction.
3. A number written in front of a chemical symbol or formula is a subscript.
4. According to the law of conservation of molecules, matter can either be created or destroyed in a chemical change.

III – Write word equation for each of the following reactions:

1. The sugar (glucose), which is present in many fruits and vegetables, reacts in the presence of a certain enzyme to produce ethanol and carbon dioxide.
2. An antacid tablet has sodium carbonate as the active ingredient. It is used to relief stomach burn. The reaction of the antacid with stomach acid, hydrochloric acid, gives sodium chloride, water and carbon dioxide.
3. Solutions of sodium hypochlorite are sold as a bleach (such as Clorox). They are prepared by the reaction of chlorine with sodium hydroxide. The products are sodium chloride, water and sodium hypochlorite.

IV - Answer the following questions:

1. Write the balanced chemical equation for each of the following word equations:

a) Hydrogen + Nitrogen → Ammonia

b) Carbon monoxide+ Oxygen →Carbon dioxide

c) Carbon dioxide + Calcium hydroxide → Calcium carbonate + Water

2. Balance the following chemical equations:

a) $C_6H_{12}O_{6(s)} \rightarrow C_2H_5OH_{(l)} + CO_{2(g)}$

b) $Na_2CO_{3(s)} + HCl_{(aq)} \rightarrow NaCl_{(aq)} + H_2O_{(l)} + CO_{2(g)}$

c) $NaOH_{(aq)} + Cl_{2(g)} \rightarrow NaClO_{(aq)} + NaCl_{(aq)} + H_2O_{(l)}$

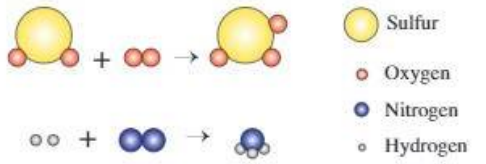
3. Write the word equation that describes each of the following unbalanced chemical equations.

a) $CH_{4(g)} + Cl_{2(g)} \rightarrow CCl_{4(l)} + HCl_{(g)}$

b) $C_6H_{6(g)} + O_{2(g)} \rightarrow CO_{2(g)} + H_2O_{(g)}$

c) $MgO_{(s)} + HCl_{(aq)} \rightarrow MgCl_{2(aq)} + H_2O_{(l)}$

4. Molecular models of chemical reactions are drawn below. Use proper coefficients to reflect balanced equations.



5. Write a paragraph about chemical reactions in everyday life, that cause pollution of the environment.
6. Conduct a library research about chemicals used in fire extinguishers.

CHAPTER *II*

Types of Chemical Reactions

Chapter Overview

In the world around us, in our bodies, in industrial processes and in chemical laboratories, thousands of chemical reactions take place.

Obviously, grouping reactions according to various similarities and regularities into meaningful classes would make it easier to deal with a reaction by comparing it to others in its class.

One system of classification is based upon the way atoms rearrange themselves in a chemical reaction.

Most reactions are either synthesis (combination), decomposition, single or double displacement reactions.

Fig. 22 Hydrogen is the fuel for the space shuttle main engine.

Chapter Contents

Classification of Chemical Reactions

The substances involved in chemical reactions can be elements or compounds. In different reactions atoms or ions rearrange themselves in different ways. Chemical reactions can be classified in several ways. The most commonly used of these classifications considers three types of chemical reactions:

Synthesis (combination), decomposition and displacement reactions – single or double.

1. Synthesis (combination) Reactions

One of the most important activities in chemistry is the synthesis of new compounds. In chemical laboratories, as well as in industry, synthesis reactions are used to produce new substances from simpler substances.

This type of reaction is represented by the following equation:

$$A + B \rightarrow AB$$

A and B are elements or compounds and AB is a complex compound.

Fig. 23a Burning of steelwool.

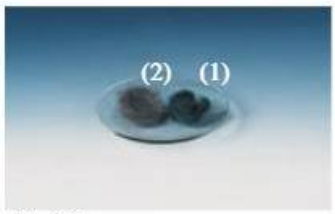


Fig.23b
1. Steelwool before burning.
2. Steelwool after burning.

Glossary

Synthesis: the word synthesis means "to put together or combine".

Activity 1a

Materials:

• Steelwool • Bunsen burner • Watch glass • Metallic tongs

Procedure:

• Grip a small bump of steelwool with a metallic tongs.
• Heat it directly on a Bunsen burner flame, for about 3 minutes.
• Put it on a watch glass and let it cool.

Activity 1b

Materials:

• Sulfur • Deflagrating spoon • Bunsen burner • Spatula

Fig. 24 Burning of sulfur. Sulfur burns with a blue flame.

Procedure:

• Place a small amount of sulfur in the deflagrating spoon. Heat directly with the Bunsen flame and then remove from the flame.

Safety

A flame hood is suggested for this activity, or a very well ventilated room.

Activity 1c

Materials:

• Calcium oxide • Watch glass • Distilled water
• Medicine dropper • Spatula

Procedure:

• Put about 1g of calcium oxide (quick-lime) on the watch glass.
• Add one drop of water and feel the watch glass underneath the solid.
• Add more water to the solid, drop-by-drop, until the reaction stops.

Analysis:

1. Describe what happens in the three activities.
2. Copy the following table in your copybook and fill in the missing terms:

Activity	Reactants	Evidence for reaction	Products	Balanced Equation
1 – a				
1 – b				
1 – c				

Safety

• Wear eye goggles. Quick-lime reacts strongly with water.
• Do not let it come in contact with your skin.

Conclusion

- A synthesis (combination) reaction involves two or more substances, elements or compounds, to form another single substance.
- Synthesis reactions often give off energy in the form of heat and light.

2. Decomposition Reactions

The decomposition of most pure substances takes place only when energy in the form of heat or electricity is used. This type of reactions is represented by the general equation:

$$AB \rightarrow A + B$$

where AB is a complex compound, A and B could be compounds or elements.

a) Decomposition of water

The decomposition of water by an electric current produces hydrogen gas and oxygen gas:

$$2H_2O_{(l)} \xrightarrow{\text{electricity}} 2H_{2\,(g)} + O_{2\,(g)}$$

Fig. 25 Electrolysis of water.

b) Decomposition by heat

Activity 2

Materials:

- Sodium bicarbonate
- Large test tube
- Heating apparatus
- Metallic tongs
- Spatula
- Wooden splint

Procedure:

- Put about 5g of sodium bicarbonate in a large test tube.
- Tap the test tube to spread the solid, then clamp it in a tilt position.
- Heat, gently at first, then heat strongly and note any changes taking place.
- Hold a burning wooden splint with metallic tongs and place it 2 cm inside the test tube.

Glossary

Electrolysis: the decomposition of a substance by electric current.

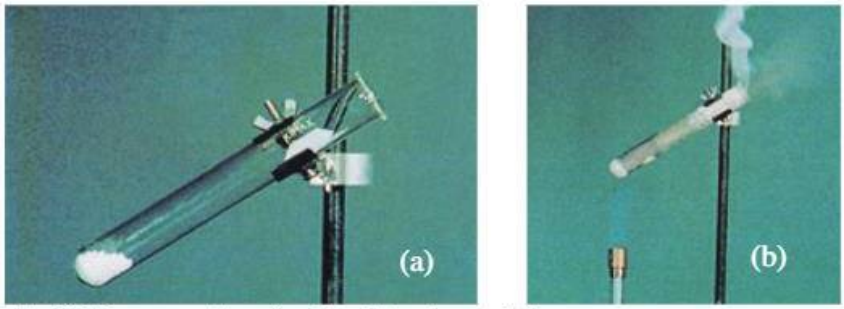


Fig. 26 Decomposition of sodium bicarbonate by heat.

Analysis:

1. What happened to the burning wooden splint? Why?
2. Is there another indication that a reaction has taken place?
3. Name the products obtained due to this chemical reaction.
4. Write the word equation and chemical equation for the decomposition of sodium bicarbonate.

Remark

Chemists often show the type of energy needed for decomposition reaction by writing a symbol above the arrow in the chemical equation.
A triangle ▲ above the arrow means that heat is needed.

Conclusion

- A decomposition reaction is just the opposite of synthesis (combination) reaction.
- The identifying characteristic of a decomposition reaction is the presence of a single compound which breaks down into two or more simpler substances.
- Energy in the form of heat or electricity is needed for decomposition reactions to take place.

3. Displacement Reactions

a) Single Displacement Reactions

In certain reactions, an uncombined element replaces an element which is part of a compound. This type of chemical reaction is called single-displacement reaction.

There are two general equations for this type of reaction.

In the first case, A replaces C as follows: $A + BC \rightarrow AB + C$

In the second case, D replaces B as follows: $D + BC \rightarrow DC + B$

The very active metal sodium must be stored in oil, not water. When it comes in contact with water, it reacts explosively. The sodium replaces the hydrogen in the water. The balanced equation is:

$$2Na_{(s)} + 2H_2O_{(l)} \rightarrow 2NaOH_{(aq)} + H_{2(g)}$$


Fig. 27 The reaction of sodium with water is exothermic.

Remark

This method of producing hydrogen is not recommended for use in school laboratories.

Activity 3

Fig. 28a Strip of zinc in copper(II) sulfate solution, at start.

Materials:

• Zinc strip • Cupric sulfate solution (1M) • 2 Beakers (250 mL)
• Copper wire • Zinc sulfate solution (1 M)

Procedure:

- Put a zinc strip in beaker (A) containing about 100 mL copper(II) sulfate solution.
- Put a piece of copper wire in another beaker containing about 100 mL zinc sulfate solution.
- Let the contents of the two beakers stand for 30 minutes.

Analysis:

1. In which beaker:
   - does the color of the solution change?
   - does the part of the metal immersed in solution change?
2. Which element has replaced another element in a compound?
3. Write word equation for the chemical reaction taking place.

Fig. 28b Copper metal atoms are deposited on the zinc strip. Almost, the reaction is complete.

Conclusion

- In a single-displacement reaction a metal replaces another metal or hydrogen in a compound.
- In a single-displacement reaction not all elements can replace all other elements.

b) Double-Displacement Reactions

When a soluble ionic substance is dissolved in water, the ions that are released behave independently of each other.

In a double-displacement reaction, cations from two different ionic compounds trade, or switch places.

The general equation for this type of reaction is given as:

$$AB + CD \rightarrow AD + CB$$

AB, CD, AD and CB are compounds.

Activity 4

Glossary

Precipitate: is an insoluble solid that forms in a solution.

Materials:

- Barium chloride solution (1M)
- Sulfuric acid solution (1M)
- Sodium carbonate solution (1M)
- Cupric nitrate solution (1M)
- 3 Beakers (100 mL)

Procedure:

- Into a beaker (A) containing about 75 mL barium chloride solution slowly pour an equal volume of sulfuric acid solution.
- Into a beaker (B) containing about 75 mL sodium carbonate solution slowly pour an equal volume of sulfuric acid solution.
- Into beaker (C) containing about 75 mL cupric nitrate solution, slowly pour an equal volume of sulfuric acid solution.

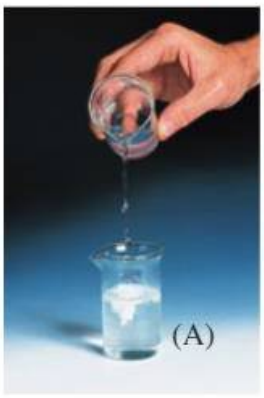


Fig. 29a Formation of precipitate

Fig. 29b Release of gas.

Fig. 29c No chemical reaction.

Analysis:

1. In which beaker does a precipitate form?
2. What is the color of the precipitate formed?
3. In which beaker is there a release of gas? Name the gas released.
4. Is there any evidence that a chemical reaction is taking place in beaker (C)?
5. Write the word equation and the unbalanced chemical equation for each of the reactions occurring in beakers (A) and (B).

Conclusion

- A double-displacement reaction is likely to proceed if a precipitate, water or gas forms when two ionic compounds are combined.
- Not all pairs of compounds will react in a double-displacement reaction.

Chapter Review

- A synthesis (combination) reaction involves two or more substances, elements or compounds, which react to form another single substance.
- Synthesis reactions, generally, are spontaneous reactions; they often give off energy in the form of heat and light.
- A decomposition reaction involves the breaking down of a single compound into two or more simpler substances.
- A decomposition reaction needs energy in the form of heat or electricity.
- In a single-displacement reaction an element replaces another element in a compound.
- In a single-displacement reaction not all elements can replace all other elements.
- A double-displacement reaction is likely to occur when two ionic compounds are combined resulting in the formation of a precipitate, water or gas.
- Not all pairs of compounds will react in a double-displacement reaction.

Remark

A list of metals arranged by reactivity is called activity series of metals.

Table 2.1 list of some metals and hydrogen according to how active they are.

Potassium	most active
Sodium	
Magnesium	
Aluminum	
Zinc	
Iron	
Hydrogen	
Copper	
Silver	
Gold	least active

Insights

List of Activity Series of Selected Metals

A simple displacement reaction occurs when a piece of copper wire is placed in silver nitrate solution. The element copper, which is more active than the element silver, replaces the silver forming a blue solution and the silver appears as an insoluble solid.

Fig. 30 On the left, the copper wire is just beginning to react. On the right, the reaction is complete. Silver crystals have covered the wire and the blue color shows that copper (II) nitrate is in solution.

An element will replace any element beneath it in the table of activity series.

Notice that the coinage metals copper, silver and gold are near the bottom of the list. Their inactivity is the reason why these elements often occur in nature, as relatively, pure elements. Most other elements occur as compounds.

Science and Society

HOT and COLD PACKS

Instant hot and cold packs release or absorb energy (heat). The cold packs used in first aid for athletes and in hospital emergency rooms, are especially useful where ice is not available; they make use of an endothermic reaction. The pack contains ammonium nitrate and water separated by a thin membrane.

The pack is activated by breaking the membrane (all you have to do is to squeeze the pack to mix the components).

When ammonium nitrate is mixed with water, energy (heat) is absorbed from the water, thus lowering the temperature of the area to which the pack is applied.

Fig. 31 Cold packs, like the one shown, are used to treat athletic injuries.

$$(\text{Heat}) + \text{water} + NH_4NO_{3\,(s)} \rightarrow NH_4NO_{3\,(aq)}$$

When the cold pack is placed on an injured area, swelling, pain and tissue damage are minimized.

The hot pack contains calcium chloride. The calcium chloride dissolves exothermically. The resulting reaction produces heat for several hours.

Questions and Exercises

I – Write the word(s) or formula(s) that best complete(s) each statement.

1. The type of reaction which occurs when two substances combine to form a single substance is..... or..... reaction.

2. The combustion of magnesium with..... in air forms a..... of formula.....

3. The pollutant $SO_{2(g)}$ reacts with oxygen in air to form $SO_{3(g)}$. The sulfur trioxide (SO_3) reacts with water droplets in air to form sulfuric acid H_2SO_4.
   These reactions are examples of..... reactions.

4. Upon heating mercuric oxide with formula....., it breaks down into..... and..... The type of reaction which occurs is..... reaction.

5. Zinc metal is more active than copper metal. Zinc can..... copper from $CuSO_{4(aq)}$ to form $ZnSO_{4(aq)}$ and..... metal.

II – Write "T" if the statement is true and "F" if it is false. Change the underlined word(s) to make the statement true.

1. In a single displacement reaction, there is only one product.

2. Two or more substances combine to form one substance in a decomposition reaction.

3. In a synthesis reaction, the product formed is sometimes a compound.

4. Single-displacement reaction is the opposite of a decomposition reaction.

5. The electrolysis of water is a single-displacement reaction.

III – Match the terms in column (A) to the descriptions given in column (B)

Column (A)	Column (B)
1. Decomposition	(a) One element replaces another element in a compound.
2. Single-displacement	(b) Decomposition using an electric current.
3. Precipitate	(c) The opposite of synthesis reaction.
4. Electrolysis	(d) Solid that settles down in the solution during double displacement reaction.
5. Synthesis	(e) A more complex substance is formed from two simpler substances.

IV – Answer the following questions:

1. Identify each of the following reactions as synthesis, decomposition, single-displacement or double-displacement.
   a) $2Ca_{(s)} + O_{2(g)} \rightarrow 2CaO_{(s)}$
   b) $2K_{(s)} + 2H_2O_{(l)} \rightarrow 2KOH_{(aq)} + H_{2(g)}$
   c) $NaOH_{(aq)} + HCl_{(aq)} \rightarrow H_2O_{(l)} + NaCl_{(aq)}$
   d) $SO_{3(g)} + H_2O_{(l)} \rightarrow H_2SO_{4(aq)}$
   e) $Fe_{(s)} + CuSO_{4(aq)} \rightarrow Cu_{(s)} + FeSO_{4\,(aq)}$

2. The eruption of a volcano is the result of a chemical reaction. Use library references to

find out what type of chemical reaction takes place and what substances are involved.

3. Make a model to show the three types of chemical reactions. One way to do this is to cut circles of different color paper to represent the atoms that are involved in chemical reaction. Then use the circles to show how atoms combine and separate during each type of reaction.

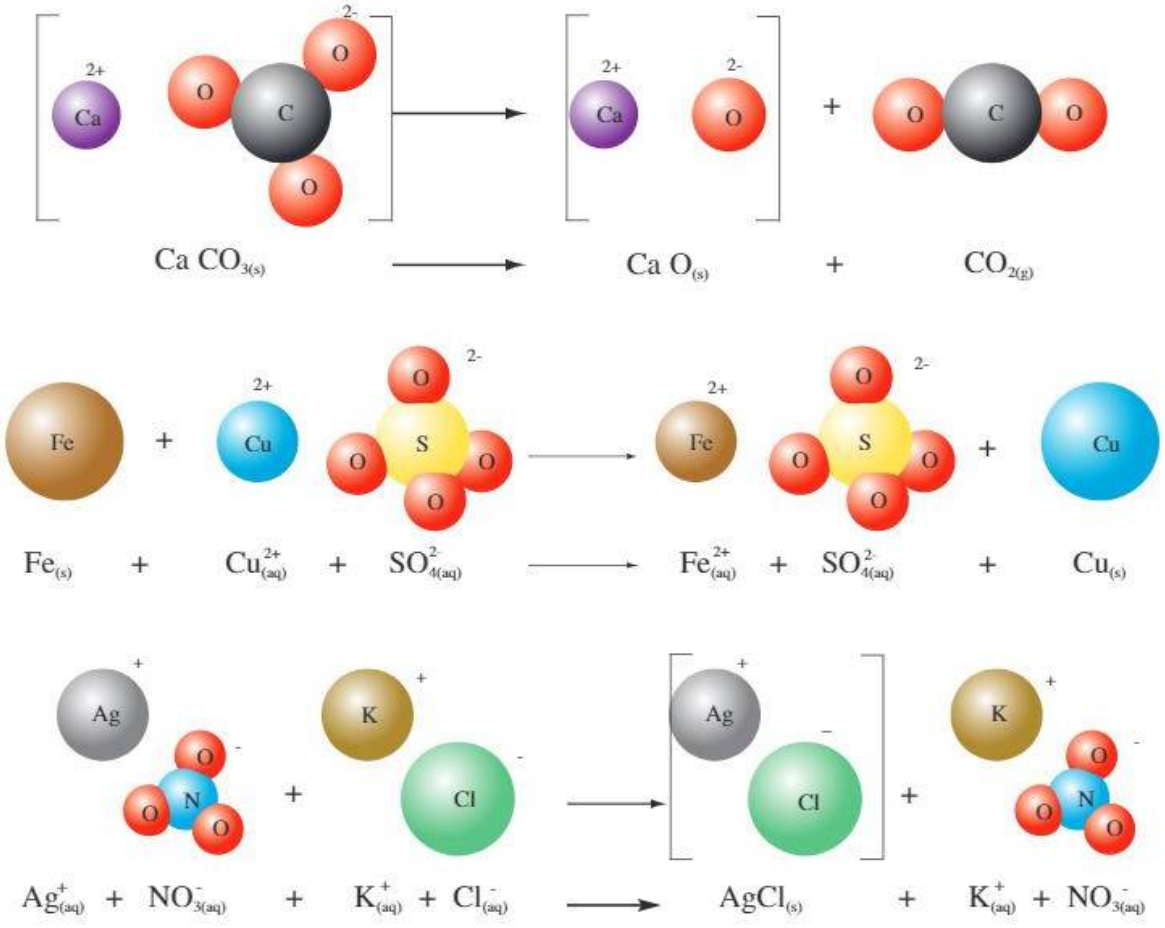
4. Design an experiment to solve the problem.

Problem: What are the products when glucose, $C_6H_{12}O_6$, is decomposed by heating?

Your experiment should:

1. List the materials you would need.
2. Identify safety precautions that should be followed.
3. List a step-by-step procedure.

5. Identify the type of each of the chemical reactions and write the word equations describing the reactions depicted in the diagram below.



CHAPTER *III*

Rates of Chemical Reactions

Chapter Overview

Chemical reactions take place at different rates, or speeds.

The rate at which any chemical reaction proceeds is an important characteristic of that reaction.

Why one reaction is fast and another is slow depends on several factors that affect the rate of reaction. Among these factors are the temperature and the catalyst.

Fig. 32 One of the most important characteristics of explosion is the speed "rate" at which it occurs.

Chapter Contents

1 Fast and Slow Reactions

The rate, or speed, of a chemical reaction reveals how quickly, during a chemical reaction, reactants are changed into products over some time interval. That time interval might be as short as a fraction of a second, as in the detonation of a stick of dynamite, or as long as a hundred year, during which some hazardous waste products decompose.

Each reaction proceeds at its own rate. Some reactions are naturally faster or slower than others under the same conditions.

A chemical reaction is referred to as fast or slow depending on how long it takes to occur.

Fig. 33 Food provides energy for human activities.

Fig. 34 Combustion of fuel in a race car provides the energy necessary for the engine to operate.

Fig. 35 Nutrients provide energy needed for the growth of a tree.

The metabolism of food to provide energy for human activities, the growth of trees and the combustion of fuel in a race car, all result from chemical reactions having different reaction rates.

2 Factors Affecting the Rate of Reaction

At room temperature, meat and dairy products rapidly begin to decay as a result of chemical reaction. In the refrigerator, food lasts for weeks and in the colder environment of the freezer, it lasts for months.

Photographic films and batteries remain useful for a longer time if they are kept cool, because the lower temperature slows the reactions that can ruin these products.

2.1. Effect of temperature

Activity 1

Materials:

- Vitamin C
- 2 Beakers (250 mL)
- Cold water at 10°C
- Warm water at 40°C
- Thermometer

Procedure:

- Fill about 100 mL of cold water at 10°C in beaker (A), 100 mL of warm water at 40°C in beaker (B).
- Drop a vitamin C tablet into each beaker and observe the reaction that occurs in each beaker.

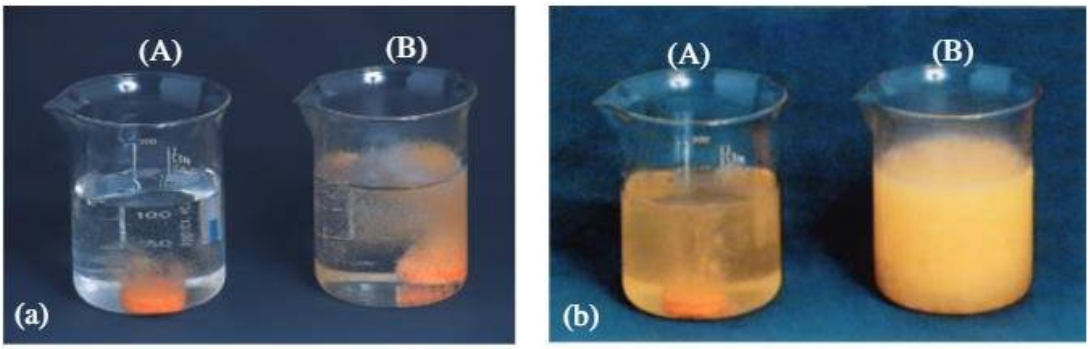


Fig. 36 Vitamin C when added to water decomposes "fizzes" quicker in hot water than in cold water. a) Newly added, b) After 2 minutes.

Analysis:

1. Is there any noticeable difference in the reactions taking place in the two beakers?
2. What effect, if any, does temperature have on this kind of reaction?

Conclusion

An increase in temperature, generally increases the rate of a reaction.

Glossary

Catalyst: A catalyst is a substance that changes the rate of a reaction without itself being consumed.

Enzyme: Enzyme is a large molecule, usually protein, that catalyzes biological reactions.

2.2. Effect of Catalyst

Some reactions take place slowly. The rates for such reactions can be increased by using catalysts. In fact, our body contains thousands of catalysts called enzymes. Enzymes allow our body to speed up biological reactions that would be too slow to sustain life at normal body temperature.

Activity 2

Materials:

- 3 Test tubes labeled (1), (2), (3)
- Test tube rack
- Sand
- 15 mL, 3% hydrogen peroxide
- Spatula
- Graduated cylinder (10 mL)
- Wooden splint
- Manganese dioxide
- Beaker of hot water-bath

Fig. 37a Decomposition of H_2O_2, using manganese dioxide.

Procedure:

Remark

A piece of liver can be used instead of manganese dioxide to catalyze the decomposition of hydrogen peroxide.

- Set the three test tubes (1), (2) and (3) in a test tube rack.
- Pour 5 mL hydrogen peroxide into tubes (1), (2) and (3).
- Place a small amount (pinch) of sand in test tube (2) and same amount of manganese dioxide in tube (3).
- Light a wooden splint, blow out the flame, and insert the glowing splint into the tube (1). Repeat the same procedure for tubes (2) and (3).
- Place the three tubes in a beaker of hot water. Heat, carefully, until all the remaining H_2O_2 is driven away.

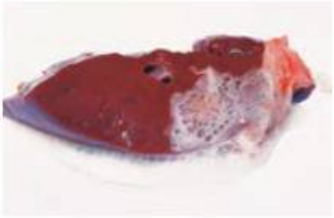


Fig. 37b Decomposition of H_2O_2 using liver.

Analysis:

1. What changes did you observe when the solids were added to the tubes (2) and (3)?
2. Which substance, sand or manganese dioxide, caused rapid decomposition of hydrogen peroxide?
3. Write the chemical equation of the decomposition reaction and name the gas produced.
4. What remained in each tube after the hydrogen peroxide was driven out?

Conclusion

A catalyst speeds up a chemical reaction without itself being used up.

Chapter Review

- The rate of a reaction is a measure of how quickly reactants change into products.
- An increase in temperature, generally increases the rate of a reaction.
- A catalyst is a substance that changes the rate of a reaction without itself being used up.
- An enzyme is a large molecule, usually protein, which catalyzes biological reactions.

Insights

Reaction Rate and Cooking of Meat

Chilling or freezing meat slows down decomposition reactions and bacterial growth. But warming the meat increases those reactions up to bacteria's maximum reproduction temperature. At temperature higher than this point, the bacteria will die.

But most bacteria do not die immediately, so that the meat must remain in contact with the higher temperature long enough for its internal temperature to rise to the point where bacteria are destroyed. Otherwise, the warm center of the meat may still bacteria that multiply freely.

Fig. 38 A time temperature monitor of food.

Chilling food slows down the rate of oxidation and enzyme action.

Modern techniques of food preparation and refrigeration have greatly reduced spoilage.

Science and Society

Catalysts in Industry

Catalysts are important in industry. A slow reaction means slow production.

Safety

Laboratory acids must be handled with care and according to instructions. They can burn your skin.

Industry makes wide use of catalysts, especially catalysts that allow companies to save on energy costs by producing large amounts of a product at a lower temperature.

An example of this occurs in the production of sulfuric acid, H_2SO_4, which is widely used by the steel, fertilizer and petroleum industries.

One step in the production of sulfuric acid involves the production of (SO_3) sulfur trioxide from sulfur dioxide (SO_2) and (O_2). The rate of this reaction is quite slow even at high temperatures. However, the reaction has been made economically worthwhile by the use of a catalyst, finely divided platinum, which greatly increases the rate of the reaction:

$$S_{(s)} + O_{2(g)} \rightarrow SO_{2(g)}$$

$$2SO_{2(g)} + O_{2(g)} \rightarrow 2SO_{3(g)}$$

$$SO_{3(g)} + H_2O_{(l)} \rightarrow H_2SO_{4(l)}$$

Fig. 39 Sulfuric acid is used as an electrolyte in car batteries

Questions and Exercises

I – Write the word(s) that best complete(s) each statement:

1. When the time interval of occurrence of reaction is short, the reaction is.....; when it is long, the reaction is.....

2. Temperature and catalysts are among the factors on which the..... of chemical reactions depend.

3. Chemical reactions occuring in living things are accelerated by special catalysts called.....

4. A piece of liver can be used as a ..... in the decomposition of hydrogen peroxide.

5. The use of catalyst, such as finely divided platinum, greatly ..... the rate of the reaction.

6. Chilling or freezing meat ..... decomposition reactions and bacterial ..... But warming the meat ..... those reactions.

II – Write "T" if the statement is true and "F" if it is false. Change the underlined word(s) to make the statment true.

1. The rate of combustion of gasoline is <u>slow</u> but the corrosion of iron is <u>fast</u>.

2. The rate of a <u>slow</u> chemical reaction can be increased using a substance called <u>catalyst</u>.

3. In general, when the temperature of a chemical reaction is increased, the reaction <u>slows down</u>.

4. Food can be conserved for an <u>unlimited</u> time when kept in the refrigerator, because cold <u>stops</u> spoiling of food.

III – Circle the letter of the answer that best completes each statement:

1. Living organisms use catalysts to speed up their reactions. These catalysts are called:
   a) inhibitors
   b) oxides
   c) enzymes
   d) sugars

2. The presence of a catalyst will:
   a) not affect the rate of chemical reaction
   b) decrease the rate of the reaction
   c) slow or partially stop the reaction
   d) increase the rate of the reaction.

3. Which of the following statements is true?
   a) All chemical reactions can speed up by increasing the temperature.
   b) Enzymes are biological catalysts.
   c) Adding a catalyst to the reaction causes the reaction to stop.
   d) Meat is preserved longer when stored in a refrigerator rather than in a freezer.

Unit Four

Acids, Bases and Salts

Fig.1 Acids were first recognized as substances that taste sour.

Unit Overview

Acids, bases and salts play important roles in living things and in industry. There are biological reactions in our bodies that carefully control the acidity -pH- of our blood. For a healthy growth of plants, farmers control the soil's pH.

The properties of acids, bases and salts help explain many phenomena. The results of acid rain and the excessive use of fertilizers harm both living and non-living things in many ways.

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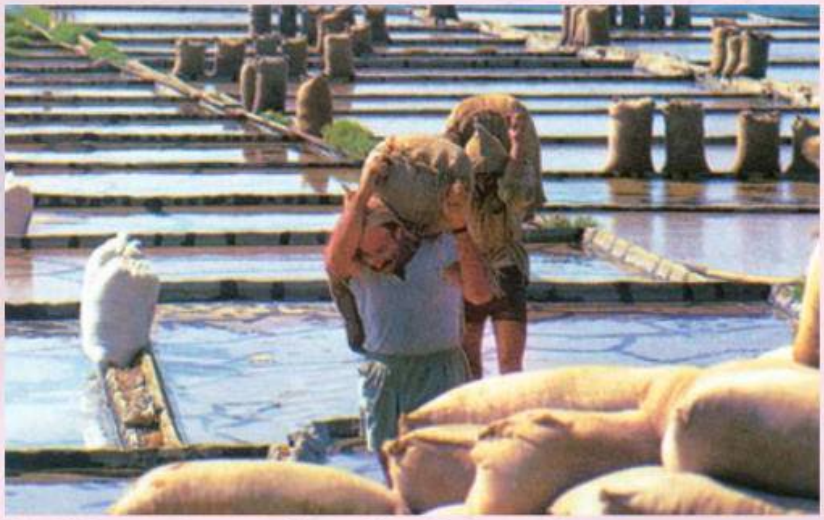


Fig. 2 Seawater is trapped in small ponds, the sun's heat evaporates away the water, leaving behind the salt.

Fig. 3 Damaging effect of acid rain on a limestone statue.

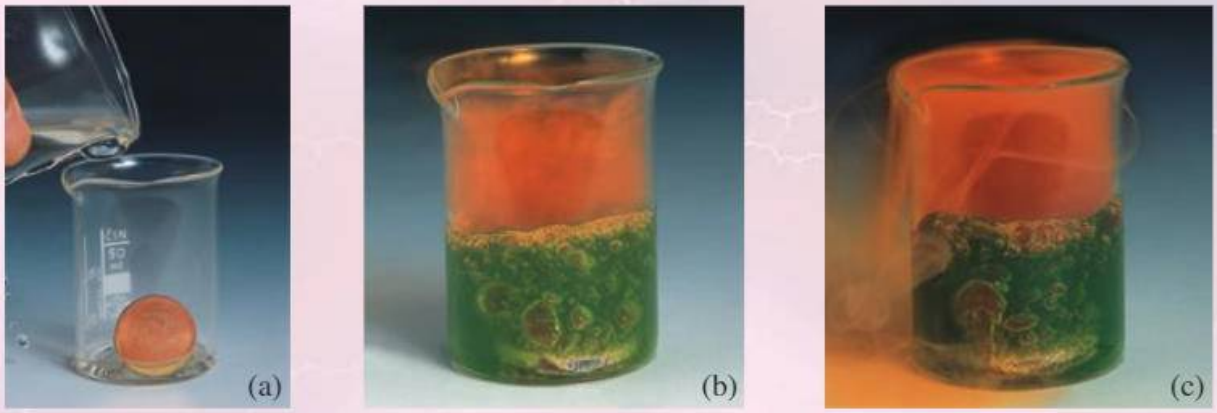


Fig. 4 A copper penny reacts vigorously with concentrated nitric acid as this sequence of photographs shows. The dark red-brown vapors are nitrogen dioxide gas.

CHAPTER *I*

Acidic and Basic Solutions

Chapter Overview

Acids are often thought of as dangerous and harmful. While this is true for some acids, other acids are not harmful and are even necessary for life. The properties of acids and bases help explain their use in daily life and in industry. Moreover, the use of a pH scale makes it possible to measure the relative acidity of a solution.

Fig. 5 Many household materials are solutions of acids and bases.

Chapter Contents

1 Acids and Bases Used in Everyday Life

Acids are components of many foods. They cause some food to be sour. The gastric juice in your stomach contains an acid that helps break down food during digestion, and some acids dissolve your tooth enamel to form cavities. Some acids are used in the manufacture of car batteries, plastics, and other products.

Safety

- If you spill an acid on your skin or get some in your eyes, be sure to flood the area immediately with water.
- Most commercial and laboratory acids are corrosive substances.
- Never eat or drink any laboratory chemical.
- Do not touch any laboratory chemical, or place it on your skin or clothing.

Fig. 6 The label on a bottle of concentrated hydrochloric acid shows symbols designed to alert the user to possible dangers.

Fig. 7 Vinegar, butter and a variety of fruits contain acids. Citrus fruits get their name from the citric acid they contain.

Fig. 8 A car battery contains sulfuric acid.

Fig. 9 Acetylsalicylic acid is the main ingredient in aspirin. Aspirin is used to reduce pain and inflammation.

Table 1.1 Some Common Acids and Their Uses

Name	Formula	Uses
Acetic acid	$HC_2H_3O_2$	Vinegar
Acetylsalicylic acid	$HC_9H_7O_4$	Aspirin
Carbonic acid	H_2CO_3 (unstable)	Carbonated drinks
Hydrochloric acid	HCl	Gastric juice in stomach
Sulfuric acid	H_2SO_4	Car batteries, plastics, detergents and fertilizers

Bases are an important group of chemical compounds. Many household products contain bases. In the pure, undissolved state, most bases are crystalline solids.

In solution, bases feel slippery and have a bitter taste.

Safety

- Never taste or touch to test the presence of a base.
- Like acids, strong bases are corrosive and contact with skin may result in severe burns and tissue damage.
- Ammonia is a colorless gas with a distinctive irritating odor. Avoid inhaling it.

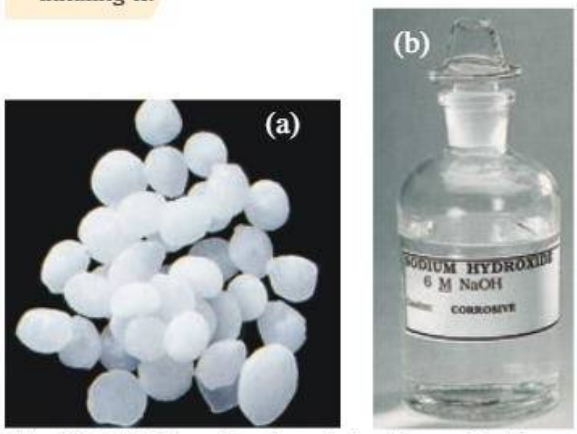


Fig. 10 (a) Pellets of sodium hydroxide gradually draw moisture from the air. (b) Sodium hydroxide is a strong corrosive base.

Fig. 11 Common household products contain bases.

Table 1.2 Some Common Bases and Their Uses

Name	Formula	Uses
Magnesium hydroxide	$Mg(OH)_2$	Laxative, antacid
Sodium hydroxide	NaOH	Drain cleaner, soap making
Ammonia	NH_3	Household cleaner, fertilizer

Fig. 12 Cabbage juice changes color when acids or bases are added.

Everyday Indicators

Many everyday substances are indicators. Grape juice and tea are good acid-base indicators.

Red cabbage, beets, cherries and berries can also be used to prepare indicators.

Materials:

• Red cabbage • Water • Beakers • Stainer • Heating apparatus

Procedure:

• In a beaker half-filled with water boil several red cabbage leaves cut into pieces.

- Let the mixture cool then pour the liquid through a stainer into the other beaker.
- This natural indicator can now be used as an acid-base indicator in the suggested amount; about one drop for every milliliter of the sample to be tested.

Glossary

Indicator: a substance that changes color in acids and in bases.

Phenolphthalein is an acid-base indicator.

2 Properties of Acids and Bases

1.2. Classification of Solutions into Acidic and Basic Solutions

Tasting is not a safe way to classify a solution into acidic or basic solution.

Most of the solutions used in everyday life such as liquid soap, glass cleaner, fruit juices, vinegar and others, can be classified into acidic or basic solutions according to how they change the colors of acid-base indicators.

Fig. 13
Acid + Phenolphthalein.

Activity 1

Materials:

- Vinegar (white)
- Red and blue litmus paper
- Shampoo
- Phenolphthalein (colorless)
- Aspirin in water
- Sea water
- Red cabbage juice
- Distilled water
- Medicine dropper
- Tap water
- 2 Test tube racks
- Test tubes
- Glass cleaner

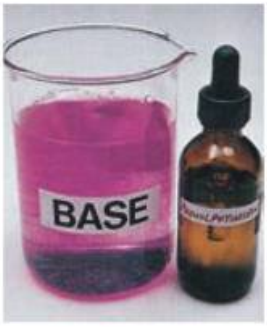


Fig. 14
Base + Phenolphthalein.

Procedure:

- Put a drop of vinegar on a piece of blue litmus paper and another drop on a piece of red litmus paper. Note the change in color.
- Into a test tube 1/3 filled with vinegar, add 3 drops of red cabbage juice and note the change in color.
- Into a test tube 1/3 filled with vinegar, add 3 drops of phenolphthalein and note the change in color, if any.
- Repeat the above procedure with the other solutions.

Remark

Be sure to clean the dropper between uses.

Analysis:

1. Copy this table on your copybook and record the results you obtain.

Solution used	Red Litmus turns to	Blue litmus turns to	Phenolphthalein turns to	Cabbage juice turns to	Nature of solution
Vinegar					

2. Is there a liquid which does not bring a color change for either red or blue litmus paper?
3. Which liquids can be classified in the same group? Why?
4. Did all acidic solutions bring the same color change with red cabbage juice?

Conclusion

- The ability of a substance in solution to change the color of certain indicators is a good indication of whether the substance is an acid or a base.
- An acid in solution changes the color of blue litmus paper into red and keeps phenolphthalein colorless.
- A base in solution changes the color of red litmus paper into blue and phenolphthalein into pink.
- Neutral solutions do not change the color of indicators.
- Cabbage juice shows a wide range of colors, depending on the acidity of the solution.

Glossary

Electrolyte: A substance that conducts an electric current when it is dissolved in water.

2.2. Electrical Conductivity of Acidic and Basic Solutions

An important property of an acidic or a basic solution is that it can conduct electricity.

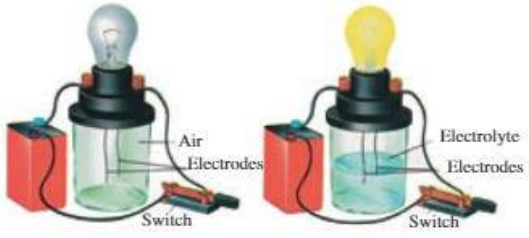


Fig. 15 Conductivity apparatus

Activity 2

Materials:

- Flashlight bulb with socket
- Dry cell
- Stirrer
- Insulated copper wires
- 3 Beakers (250 mL)
- Vinegar (white)
- Distilled water
- Sodium hydroxide (0.5 M) solution

Procedure:

- Set up the electric circuit as shown in Fig. 15.
- Pour about 50 mL distilled water in beaker (A) and dip the two ends of the wires in beaker (A). Record your observations.
- Pour about 50 mL vinegar into beaker (B) and dip the two ends of the wires in beaker (B). Record your observations.
- Pour about 50 mL sodium hydroxide solution into beaker (C) and dip the two ends of the wires in beaker (C). Record your observations.

Remark

- Do not let the wires touch each other in the beaker.
- Rinse the wires with distilled water before you dip them in the basic solution.

Analysis:

1. Is pure (distilled) water a poor conductor of electric current? Why?
2. What does the conductivity of vinegar or sodium hydroxide solution indicate?

Conclusion

- A solution that contains ions is a good conductor of electricity.
- Acidic and basic solutions are electrolytes, they contain ions in solution.
- An acid (HX), when dissolved in water ionizes to produce a positive ion H^+ (aq) and a negative ion, X^- (aq).
- A base (YOH), when dissolved in water ionizes to produce a positive ion, Y^+ (aq) and a negative ion, HO^- (aq).

Glossary

Ionize: Separate or split into ions.

2.3. Properties of Acids

All acids when dissolved in water have the ability to produce H^+(aq) ions in solution.

It is the presence of H^+ (aq) ions that gives acidic solutions their characteristic properties.

Acids, besides their sour taste, their ability to change the color of acid-base indicators and their electrical conductivity, have some other common properties.

Remark

Not all compounds containing hydrogen are acids.

Activity 3

Safety

- Handle hydrochloric acid with care.
- Report any spills immediately.

Materials:

- Zinc granules
- Hydrochloric acid solution (0.5 M)
- Matches
- Test Tube
- Rubber stopper

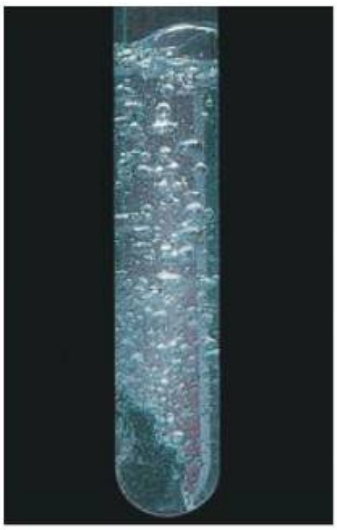


Fig. 16 The reaction of zinc with hydrochloric acid produces hydrogen gas bubbles.

Procedure:

- Place a few zinc granules in a test tube.
- Pour about 3 mL of hydrochloric acid solution into the test tube.
- Stopper the test tube for about 30 seconds. Remove the stopper, then bring a lit match to the brim of the test tube. Record your observations.

Analysis:

1. Is there any visible sign(s) indicating a reaction between the acid and the metal?
2. What is the nature of the released gas?
3. Write the chemical equation of the reaction.

Activity 4

Materials:

- Acetic acid (vinegar)
- Flask
- Lime water
- Wide mouth bottle
- Powdered chalk (calcium carbonate)
- Dropping funnel
- Rubber stopper with two holes
- Bent glass tubing

Procedure:

- Put a small quantity of powdered chalk in the wide-mouth bottle.
- Half-fill a flask with lime water.
- Fit the glass tubing and the dropping funnel into the stopper and adjust the set-up as shown in Fig. 17.
- Half-fill the dropping funnel with acetic acid.
- Turn the stopcock and let the acetic acid run into the bottle. Record your observations.

Safety

Do not force the glass tubing and the dropping funnel through the holes of the stopper. Use a very small amount of lubricant.

Fig. 17 A stream of CO_2 gas causes the turbidity of clear lime water.

Analysis:

1. What visible signs indicate that a reaction took place between:
   – the acid and calcium carbonate?
   – the gas released and lime water?
2. Write the chemical equation of the reaction taking place between the acid and the carbonate.

Conclusion

- Acidic solutions react with active metals to produce hydrogen gas.
- Acidic solutions react with carbonates to produce carbon dioxide gas.

2.4. Properties of Bases

Compounds that can produce hydroxide ions HO^- in aqueous solution are classified as bases. A solution that contains HO^- ions from a soluble base is referred to as alkaline solution.

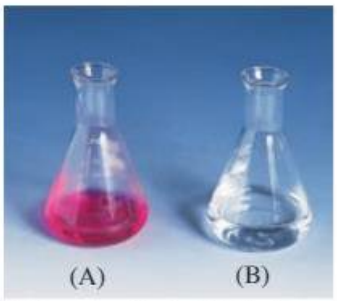
Glossary

Alkaline: the word alkaline comes from alkali, an old name for substances with the general properties of bases.

Activity 5

Materials:

- HCl solution (0.1 M)
- NaOH solution (0.1 M)
- (100 mL) Erlenmeyer flask
- Heating apparatus
- Phenolphthalein (colorless)
- Watch glass
- Medicine dropper



Erlenmeyer flask (A): Sodium hydroxide solution colored with phenolphthalein.
Erlenmeyer flask (B): Hydrochloric acid solution colored with a few drops of phenolphthalein.

Beaker (C): Hydrochloric acid solution.

Procedure:

- Place 25 mL of sodium hydroxide solution into the Erlenmeyer flask and add 2 drops of phenolphthalein. Record the color of the solution.
- Add about 24 mL of HCl acid solution into the flask, and shake well. Record the color of the solution.
- While slowly shaking the solution, carefully add hydrochloric acid, drop-by-drop, until the solution just changes color. Record the color change. (This point is known as the indicator end point).
- Carefully, pour about 5 mL of the obtained solution into a watch glass and evaporate the solution over a steam bath (Fig. 19). Record your observations.

Fig. 18 Neutralization of NaOH with HCl.

Fig. 19 Obtaining sodium chloride crystals.

Analysis:

1. What happened to the color of the solution at the indicator end point? Why?
2. Describe the appearance of the solid on the watch glass.
3. Write the chemical equation of the reaction.

Conclusion

- The reaction of an acid with a base is known as neutraliztion reaction.
- A base reacts with an acid to neutralize it. The products of such a reaction are a salt and water.

Remark

pH scale was developed in 1909 by the Danish scientist Sorensen. pH means "power of hydrogen ion".

3 Acidity and Concept of pH

The pH of a solution is a measure of the concentration of H^+ ion in solution.
To measure the acidity of a solution, the pH scale is used. The pH scale is a series of numbers from 0 → 14.
There are two common ways to measure the pH of a solution: using the pH paper or the pH meter.

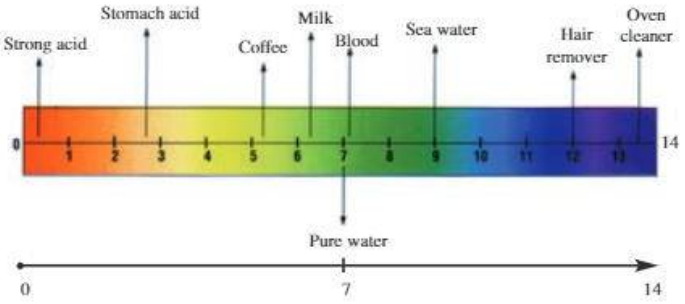


Fig. 20 The pH indicator paper is soaked with several dyes.

Activity 6

Materials:

- pH meter
- pH paper
- 6 Beakers (100 mL.)
- Distilled water
- Lemon juice
- Vinegar (white)
- Sodium bicarbonate solution
- Lime water
- Milk

Procedure:

- Pour some distilled water in a beaker.
- Dip a small strip of pH paper in the beaker.
- Compare the color of the strip of pH paper to the color code on the container and record the corresponding pH value.
- Use the pH meter to measure the pH value of the distilled water. Record the value.
- Repeat the above procedure using, respectively, the other given solutions.

Fig. 21 One way of measuring the pH of some common materials is to use pH paper or pH meter.

Analysis:

1. Which pH measurement is more accurate: Using pH paper or pH meter? Why?
2. Take the pH value of distilled water as reference and compare the pH values for other solutions.
3. Draw a horizontal line and mark on it the series of numbers 0 → 14 at a spacing of 1 cm from each other. Take the pH of distilled water as midpoint pH = 7 then classify the remaining susbtances according to their pH values.

Conclusion

- The pH scale is a series of numbers from 0 → 14
- A neutral solution has a pH of 7. A neutral solution is neither acidic nor basic.
- Acidic solutions have a pH less than 7, the lower the value of pH the more acidic is the solution.
- Basic solutions have a pH greater than 7, the higher the value of pH the more basic is the solution.
- The pH value measured by using a pH paper is less accurate than that obtained by using a pH meter.

Chapter Review

- Acids have a sour taste.
- Bases have a bitter taste and feel slippery.
- An acid in solution changes the color of the blue litmus paper into red, and keeps phenolphthalein colorless.
- A base in solution changes the color of the red litmus paper into blue, and colorless phenolphthalein into pink.
- Indicators do not change color in neutral solutions.
- A solution that contains ions is a good conductor of electricity.
- An acid, when dissolved in water, ionizes to produce H^+ (aq) ion and a negative ion.
- A base, when dissolved in water, ionizes to produce HO^- (aq) ion and a positive ion.
- Acidic solutions react with active metals to produce hydrogen gas and react with carbonates to release carbon dioxide gas.
- A base reacts with an acid to neutralize it. The products of such a reaction are a salt and water.
- The pH of a solution is a measure of the concentration of H^+ ion in solution.
- A neutral solution has a pH of 7, an acidic solution has a pH less than 7 and a basic solution has a pH greater than 7.

Fig. 22 The pH scale helps us classify solutions as acidic or basic.

Insights

1. Acidity of Soil

Plants are very sensitive to the acidity of the soil. Some soils are naturally acidic and others have basic properties.

A hydrangea that grows in acidic soils has blue flowers. If the same plant is moved to a soil that has basic properties, the flowers will turn pink.

The dye that colors the flower has two forms. One is acid and another is base. The amazing thing about this dye is that its change is reversible.

Pink hydrangeas can produce blue blooms by altering the soil conditions.

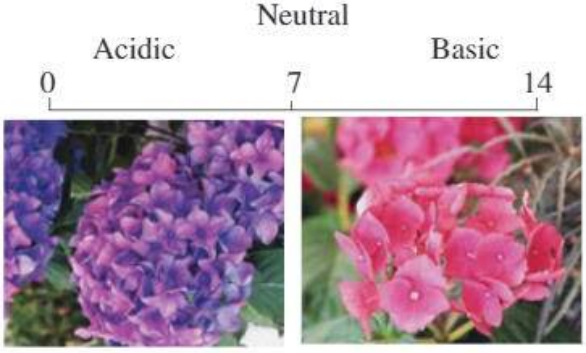


Fig. 23 Colored hydrangea, in acid and base soils.

2. Acidity of Blood

Your body keeps the pH of your blood and other body fluids between 7.3 and 7.4. Your daily activities, eating certain types of food, exercising or becoming ill, can change your blood pH. The concentration of carbon dioxide in your blood is the main factor that determines the blood's pH. Carbon dioxide reacts with water in the blood to form carbonic acid. The greater the amount of carbon dioxide in the blood the lower the pH. When your blood pH falls too low you automatically exhale larger amounts of carbon dioxide to bring the pH back in line.

Science and Society

1. Acid-Free Paper

Fig. 24 Self-destructing paper.

Most paper products contain aluminum salts. These salts help prevent ink from soaking into the paper and blurring. However, water from air can react with aluminum in salts forming acidic solutions. These acids cause damage to paper.

Since 1990, paper manufacturers have made acid-free paper using calcium carbonate instead of aluminum salts. Acid-free paper lasts a long time and is widely available and used.

2. Glass Etching

Fig. 25 Artists have used HF to etch layers of glass, leaving a beautiful object behind.

Hydrofluoric acid (HF), is a weak acid, and is only partially ionized in solution. The fact that HF is a weak acid does not mean that it is not highly corrosive and reactive. HF actually etches glass. Glass is a viscous mixture of silicates that are derived from silicon dioxide (SiO_2).

When glass is attacked with HF, the following reaction occurs.

$$SiO_{2(s)} + 4HF_{(aq)} \rightarrow SiF_{4(g)} + 2H_2O_{(l)}$$

HF is used to etch glass, to make it opaque or to produce artistic design.

Questions and Exercises

I – Write the word(s) that best complete(s) each statement.

1. A solution which feels slippery is a(n)..... It changes red litmus paper..... and phenolphthalein.....
2. A sour taste is a common property of compounds that are classified as..... They react with..... to produce carbon dioxide.
3. When an..... reacts with a..... water and a(n)..... are formed. The pH of the resulting solution is..... It is a(n)..... solution.

II – Write "T" if the statement is true, and "F" if it is false. Change the underlined word to make it true.

1. Acids react with metals to release <u>oxygen</u> gas.
2. All bases release <u>hydrogen</u> ions in water.
3. A neutralization reaction is a <u>double-displacement</u> reaction.
4. When HCl neutralizes NaOH, the resulting solution is a <u>non-electrolyte.</u>

III – Circle the letter of the answer that best completes each statement:

1. When red litmus paper is placed in an acidic solution, its color will be:
   a) red b) blue
   c) orange d) purple

2. When placed in water all bases release:
   a) chloride ions b) oxide ions
   c) hydrogen ions d) hydroxide ions

3. A neutraliztion reaction is a reaction between:
   a) an acid and a base b) an acid and water
   c) a base and water d) a salt and water

4. Electrolytes can conduct electricity when they are dissolved in water because they form:
   a) molecules b) compounds
   c) ions d) salts

5. A solution with pH = 4 is more acidic than a solution with pH:
   a) 0 b) 2 c) 3 d) 8

IV. Answer the following questions:

1. Explain why the edges of grated red cabbage change color as they get in contact with the dressing of the salad?

2. Arrange the following solutions by decreasing order of acidity:
   a) Cleaning solution (pH = 8.5)
   b) Medical soap (pH = 3)
   c) Coca Cola (pH = 3.7)
   d) Fruit juice (pH = 3.5)
   e) Saliva (pH = 6.5)

3. The symbols found on the bottle of hydrochloric acid or on the bottle of sodium hydroxide should draw your attention to some safety hazards.
   Explain the meaning of these symbols.

4. Make a display and write a report about common household acids and bases, how they are used and precautions to be taken.

5. Make a table listing the chemical and physical properties of acids and bases.

CHAPTER *II*

Salts

Chapter Overview

The word salt is used to refer to many substances that you come in contact with everyday. But most people use it to mean table salt, whose chemical name is sodium chloride. All salts are ionic compounds formed by the association of cations of bases and anions of acids.

Salts are necessary for our diet, and have important uses in industry.

Chemical reactions, in aqueous solution, can be used to identify the oppositely-charged particles constituting a salt.

The presence of ions cannot be ignored in many chemical situations.

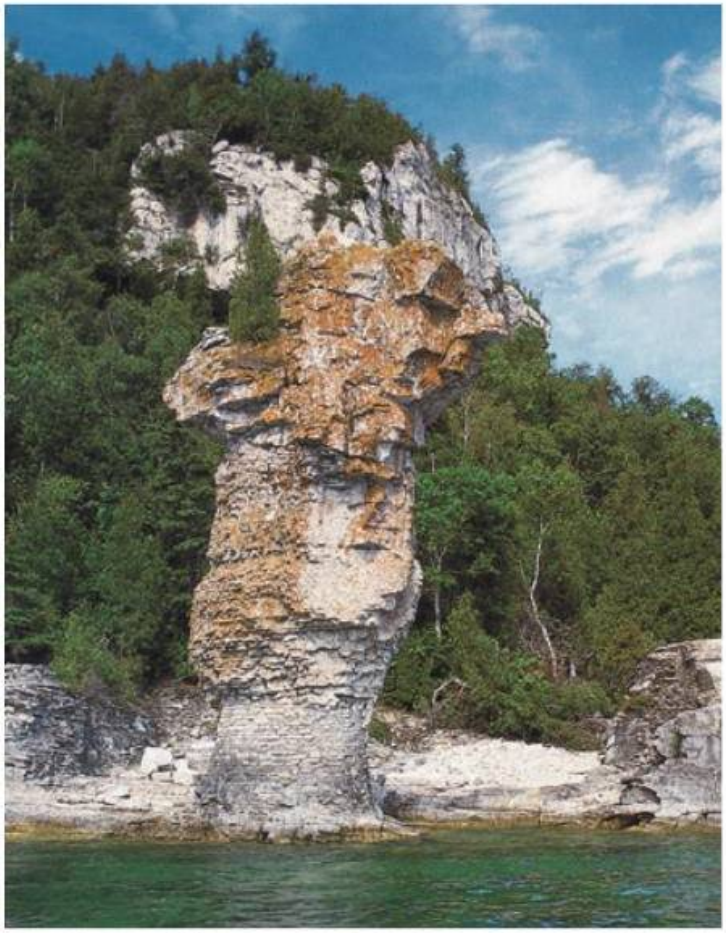


Fig. 26 The cliffs are composed of calcium carbonate which consists of calcium ions and carbonate ions.

Chapter Contents

1 Crystal Structure of Salts

Sodium chloride is an ionic compound. If you could see the individual sodium and chloride ions in a crystal of sodium chloride, you would find that they are arranged in a regular repeating pattern. (Fig. 27b).

Fig. 27a The compound NaCl appears quite different from the elements that form it.

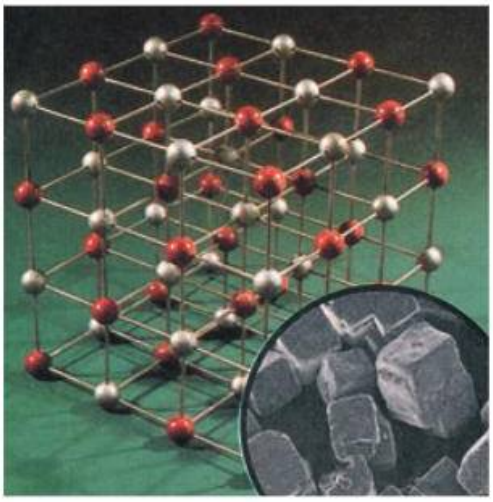


Fig. 27b The arrangement of ions in a salt crystal.

Activity 1

Materials:

- Sodium chloride
- Magnifying lens
- White cardboard
- Black cardboard
- Copper (II) sulfate
- Microscope

Glossary

"Crystal": (from Greek "Krystallos" or ice like). A substance in which the particles are arranged in an orderly 3– dimensional pattern.

Procedure:

- Put a few crystals of table salt on a piece of black cardboard.
- Examine the crystals with a magnifying lens and draw the shape of a salt crystal.
- Observe 1 or 2 small crystals using the microscope (low power magnification).
- Repeat the same activity using copper (II) sulfate crystals on a piece of white cardboard.

Analysis:

Are all crystals alike or different in shape?

Conclusion

Salts are ionic compounds with distinct crystal shapes. Crystals of salt have a definite shape which depends on the arrangement of the particles within it.

2 Preparation of Salts

2.1. Acid-Base Reaction

When a proper amount of acid is added to a base, a chemical change called neutralization occurs. The properties of the acid and the base cancel each other. Neutralization produces water and a salt. A salt is a solid ionic compound, which is neither an acid nor a base (refer to page 132, Activity-5).

2.2. Acid–Metal Reaction

Many metals react with acids; the acid fizzes as the hydrogen bubbles out.

Some metals, like silver, do not react with acids. Other metals, such as sodium, react dangerously fast. Zinc, iron and magnesium all react to produce salt solutions and hydrogen gas (refer to page 130, Activity-3).

2.3. Metal–Non-metal Reaction

The reaction of a metal with a non-metal often produces an ionic compound – a salt.

Activity 2

Materials:

- Powdered aluminum
- Water
- Iodine crystals
- 3 Petri dishes
- Pipet or dropper
- Glass rod

Procedure:

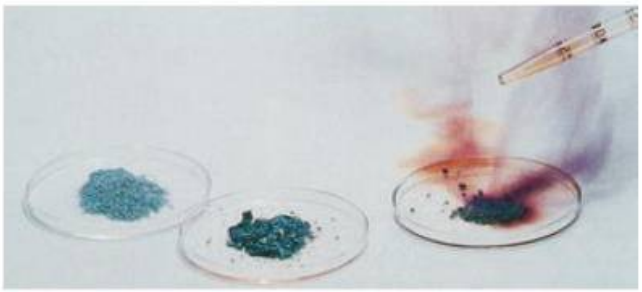


Fig. 28 The purple cloud is excess iodine vaporized by the heat of the reaction.

- Mix a small amount of aluminum powder and pulverized iodine crystals in a petri dish.
- Add a drop of water, using a pipet (Fig. 28)

Analysis:

1. Specify the type of reaction taking place and name the product formed.
2. Write the chemical equation of the reaction.

Safety

The reaction is vigorous, the mixture bursts into flames.

Conclusion

Salts can be prepared applying double-displacement reactions (acid-base reaction), single-displacement reactions (acid-metal reaction) and synthesis or (combination) reactions (metal — non-metal reaction).

3 Tests to Identify Ions

Many aqueous ions can be identified by the appearance of their precipitates or by the color of their solutions.

3.1. Identification of Some Cations

Activity 3

Formation of $Al(OH)_3$ precipitate.

Formation of $Fe(OH)_3$ precipitate.

Formation of $Fe(OH)_2$ precipitate.

Formation of $Cu(OH)_2$ precipitate.

Fig. 29 Identification of some cations.

Materials:

- 4 Test tubes
- Sodium hydroxide solution (1M)
- Dropper
- Aluminum chloride solution (1M)
- Ferric chloride solution (1M)
- Ferrous chloride solution (1M)
- Cupric chloride solution (1M)

Procedure:

- Using a dropper, add drop-by-drop sodium hydroxide solution into:
  - test tube (a) 1/3 filled with aluminum chloride solution
  - test tube (b) 1/3 filled with ferric chloride solution
  - test tube (c) 1/3 filled with ferrous chloride solution
  - test tube (d) 1/3 filled with cupric chloride solution

Analysis:

What is the color of the precipitate formed in each test tube?

Conclusion

- The formation of colored precipitate is used to identify cations.
- Aluminum $Al^{3+}_{(aq)}$ ion can be identified by the formation of white gelatinous precipitate.
- Ferric $Fe^{3+}_{(aq)}$ ion can be identified by the formation of rusty precipitate.
- Ferrous $Fe^{2+}_{(aq)}$ ion can be identified by the formation of green precipitate.
- Cupric $Cu^{2+}_{(aq)}$ ion can be identified by the formation of blue precipitate.

3.2. Identification of Some Anions

Activity 4

Chloride Cl^-(aq) ion

Materials:

- Test tube
- Silver nitrate solution (1M)
- Dropper
- Sodium chloride solution (1M)

Procedure:

- Into a test tube 1/3 filled with silver nitrate solution, add drop-by-drop sodium chloride solution. Observe what happens.

Analysis:

What is the color of the precipitate formed?

Fig. 30 Formation of white precipitate $AgCl_{(s)}$.

Remark

The formed white precipitate turns black (tarnishes) when exposed to light.

Activity 5

Sulfate SO_4^{2-} (aq) ion

Materials:

- Test tube
- Sodium sulfate solution (1M)
- Dropper
- Barium chloride solution (1M)

Procedure:

- Into a test tube 1/3 filled with barium chloride solution add, drop-by-drop sodium sulfate solution.

Analysis:

Observe what happens.

Fig. 31 Formation of white precipitate $BaSO_{4(s)}$.

Remark

The white precipitate is insoluble in acidic solution.

Activity 6

Phosphate PO_4^{3-} (aq) ion

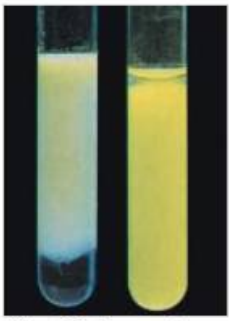


Fig. 32 Formation of yellow precipitate $Ag_3PO_{4(s)}$.

Materials:

- 2 Test tubes
- Silver nitrate solution (1M)
- Dropper
- Sodium phosphate solution (1M)

Procedure:

- Into a test tube 1/3 filled with sodium phosphate solution add drop-by-drop silver nitrate solution.

Analysis:

What is the color of the precipitate formed?

Safety

Concentrated sulfuric acid is very corrosive. Take all precautions needed when handling concentrated sulfuric acid.

Activity 7

Nitrate NO_3 (aq) ion

Materials:

- 2 Test tubes
- Sodium nitrate solution (1M)
- Distilled water
- Ferrous sulfate crystals
- Sulfuric acid solution (6M)
- Spatula

Remark

The test performed to detect the presence of NO_3^- ion in solution is called "Brown ring test".

Procedure:

- Into a test tube containing about 5 mL distilled water, dissolve some iron(11) sulfate crystals.
- Into a test tube 1/3 filled with sodium nitrate solution (held in tilted position), pour about 2 mL of the freshly prepared ferrous sulfate solution then carefully pour about 2 mL concentrated sulfuric acid solution.

Analysis:

What is the color of the ring formed?

Activity 8

Carbonate CO_3^{2} (aq) ion

Insoluble carbonates such as calcium carbonate or soluble carbonates such as sodium carbonate react with acidic solutions to produce carbon dioxide gas which turns clear lime water milky.
(see Fig. 15, page 131, Activity-4).

Analysis:

1. What happens if a continuous stream of $CO_{2(g)}$ is bubbled into lime water?
2. Write the chemical equation of the reaction.

Activity 9

Sulfite SO_3^{2} (aq) ion

Materials:

- Test tube
- Sodium sulfite solution (1M)
- Rubber stopper
- Hydrochloric acid solution (1M)

Remark

Sulfur dioxide has a choking odor. Don't inhale it.

Procedure:

- Into a test tube 1/3 filled with sodium sulfite solution, pour an equal volume of hydrochloric acid solution and stopper the test tube for a minute.
- Remove the stopper and fan the vapor toward your nose.

Safety

Test for odor:
- Never hold your nose directly over the vessel.
- Wear eye goggles.

Analysis:

1. What is the nature of the gas released?
2. Write the chemical equation of the reaction.

Conclusion

- The formation of colored precipitate or liberation of gas can be used to identify anions.
- Chloride $Cl^-_{(aq)}$ ion can be identified by the formation of white precipitate which darkens when exposed to light.
- Sulfate $SO^{2-}_{3(aq)}$ ion can be identified by the formation of white precipitate.
- Phosphate $PO^{3-}_{4(aq)}$ ion can be identified by the formation of yellow precipitate.
- Nitrate $NO^-_{3(aq)}$ ion can be identified by the formation of brown ring.
- Carbonate $CO^{2-}_{3(aq)}$ ion can be identified by the formation of CO_2 gas which turns clear lime water milky.
- Sulfite $SO^{2-}_{3(aq)}$ ion can be identified by the formation of SO_2 gas which has choking odor.

Chapter Review

- Salts are ionic compounds formed by the association of cations of bases, and anions of acids.
- Salts are ionic compounds with distinct crystal shapes.
- Crystals of a salt have a definite shape which depends on the arrangement of the charged particles constituting it.
- A salt is a product of neutralization reaction of an acid with a base.
- A salt is a product of acid-metal reaction.
- A salt is a product of the synthesis reaction of a metal with non-metal.
- Cations and anions can be identified by the formation of colored precipitate or the liberation of a gas.

Insights

"Natural Salts"

Rain water dissolves a little carbon dioxide from the air and becomes a very dilute weak acid. It gradually dissolves rocks as soluble salts. Small amounts of these salts are essential to plant growth. Plants absorb them through their roots from the water that is trapped in the soil. Most of the salts are washed away in streams and rivers and collect in the sea. The large deposits of natural salts found in many parts of the world were formed when seas dried up millions of years ago.

Quite often natural salts are found as beautifully colored and shaped crystals.

Dietary salt sodium chloride is so important that in Roman times, workers received part of their pay as salt: it was called salarium, the root word for salary. This also explains the expression that certain people are not "worth their salt."

Farmers and wildlife managers know the importance of adequate amounts of salt in animal diets. They sometimes put a salt lick – a large cube of sodium chloride – in a pasture for animals to lick.

Fig. 33 A salt lick provides NaCl for wildlife animals.

Table 1 – Some Salts and their Uses

Name	Formula	Uses
Ammonium sulfate	$(NH_4)_2SO_4$	Fertilizer
Calcium chloride	$CaCl_2$	De-icing roadways and sidewalks
Potassium chloride	KCl	Sodium-free salt substitute
Potassium permanganate	$KMnO_4$	Disinfectant and fungicide
Silver bromide	AgBr	Photographic emulsions
Sodium hydrogen carbonate (baking soda)	$NaHCO_3$	Antacid
Sodium chloride (table salt)	NaCl	Body electrolyte; chlorine manufacture

Science and Society

COMMON SALT - Sodium chloride

Fig. 34 Deposits of salt are found where prehistoric inland seas have dried up.

Sodium chloride or common salt is an essential part of our diet. Today it is the starting material for many important chemical processes.

• How salt is obtained

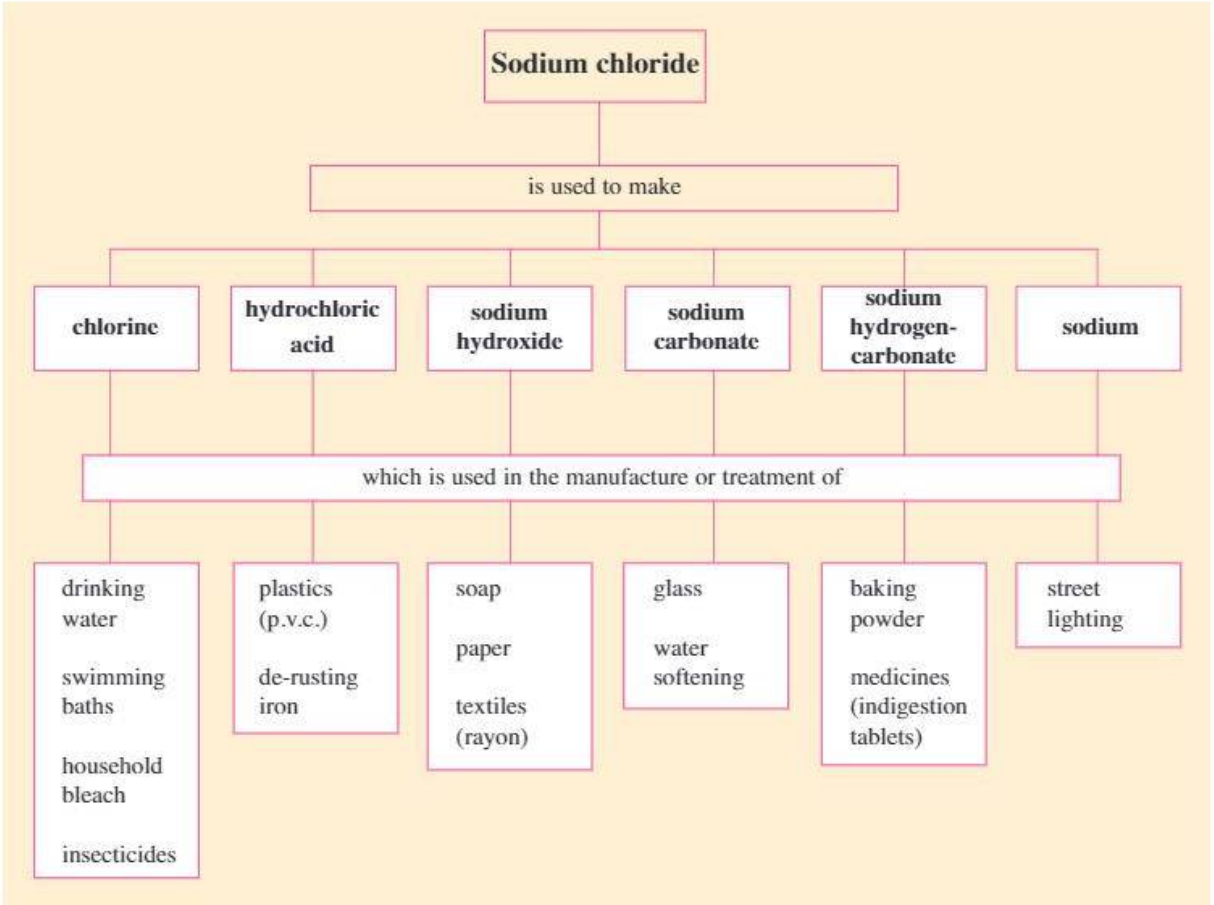
The huge quantities of salt required by industry come from seawater which contains 2.7% by mass of salt. Sea water is trapped in large, shallow pools where the sun evaporates the water. The deposits of salt left behind are scooped up by mechanical diggers.

Solid salt is also found underground, rock salt is mined like coal.

• Uses of Sodium chloride

Sodium chloride in its natural state is used for de-icing roads and as a fertilizer. Other grades of crystals are used for dyeing and leather-making.

• Important Chemicals Obtained from Sodium chloride and their Uses.



Questions and Exercises

I – Write the word(s) that best complete(s) each statement.

1. A..... is always formed in a neutralization reaction.
2. Soluble salts can..... electricity when they are dissolved in water because they separate into.....
3. Acid rain containing sulfuric acid reacts with iron objects to produce hydrogen gas and a.....
4. Sodium hydroxide NaOH is a..... and not a salt because it consists of cation Na^+ and anion.....
5. When silver nitrate is added to sodium chloride, a white..... is formed. called...

II – Answer the following questions

1. Write the balanced equation showing neutralization of:
   a) KOH with HCl
   b) Ba $(OH)_2$ with HNO_3

2. Write the equation of the reaction for the formation of the salt KCl by:
   a) neutralization reaction
   b) hydrogen displacement by a metal
   c) combination of the elements
3. Three salts – calcium nitrate, potassium chloride and sodium sulfate – were obtained in reactions of acid-base pairs given as:
   HCl + KOH; $Ca(OH)_2$ + HNO_3 and NaOH + H_2SO_4. Write the formula of each salt and match each salt with the acid-base pair that produced it.
4. Both chloride Cl (aq) ion and sulfate SO_4^{2-} (aq) ion are identified by the formation of a white precipitate.
   a) What are the different reagents used to identify these ions?
   b) What difference do you observe when the two precipitates are exposed to light?
5. Use library reference to find out how salt is obtained from sea water. Describe this process.
6. Why should you never taste an unknown substance to identify it as an acid or a base? How else can you identify it?

III - Design an experiment to solve the problem.

Problem: How can you identify a substance as an electrolyte or a non-electrolyte?

Your experiment should:

1. List the materials you would need.
2. Identify safety precautions that should be followed.
3. List a step-by-step procedure.
4. Describe how you would record your data.

CHAPTER *III*

Applications

Acid-Base Reactions in the Environement

Chapter Overview

Some typical acid-base reactions can have serious impacts on the environment. One example is acid rain which results from air pollution. However, these reactions have been applied in medicine to control and regulate biological processes. One example is the use of antacid, which relieves heartburn due to indigestion. On the other hand, farmers use fertilizers and chemicals to adjust the pH of soil to improve crops yield.

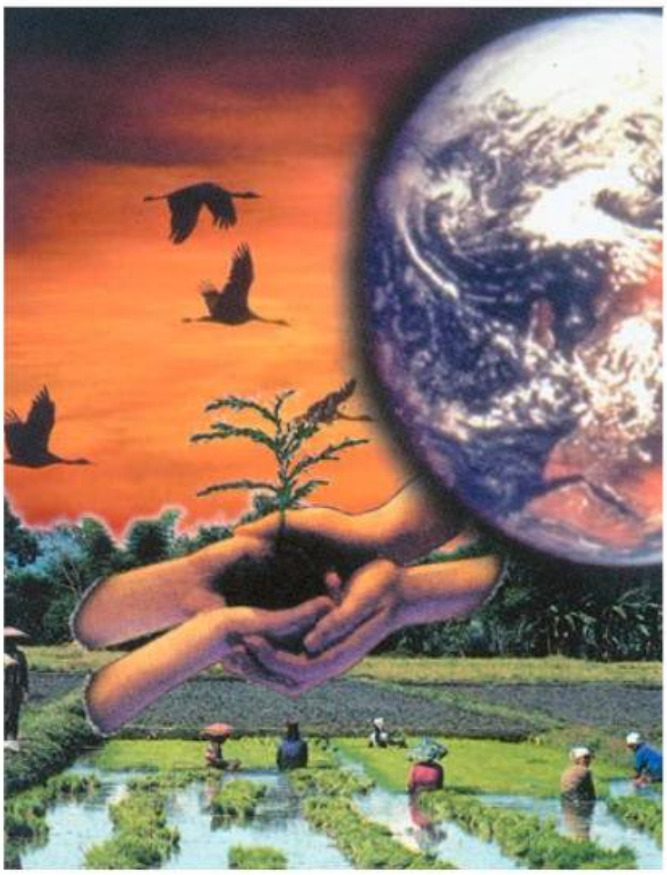


Fig. 35 It is essential to protect land and other fixed resources, such as our air and water.

"The nation that destroys its soil destroys itself."

Chapter Contents

1 Acid Rain

Even in a clean air, where no pollutants have entered the atmosphere, rain and snow are slightly acidic. Carbon dioxide produced by natural processes combines with water in the atmosphere forming carbonic acid (H_2CO_3). The pH of normal rainfall is generally between 5.0 and 5.6. Gaseous air pollutants can acidify the rain. Acid rain refers to rain with pH less than 5.0.

Glossary

Pollutant: Any natural or human-made substance that is present in quantities that make it undesirable or harmful.

1.1. Sources of Acid Rain

The major source of chemicals that produce acid rain are human activities.

Electrical power plants, smelters and industries use fossil fuels. Fossil fuels such as coal, oil and natural gas contain large amounts of sulfur. When they are burned, sulfur dioxide and nitrogen oxides are released high into the air. These gases dissolve in the water droplets of the clouds to form acid droplets which may be carried by the wind over long distances, before they fall as acid rain.

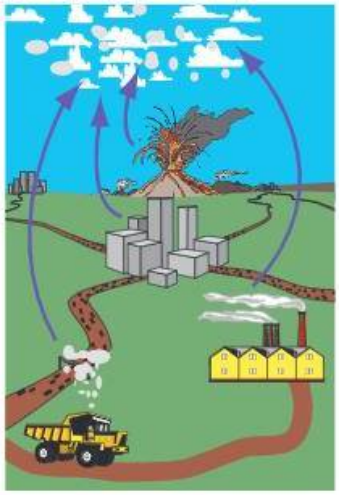


Fig. 36 Human sources and natural sources that contribute to air pollution.

1.2. Effects on the Environment

A. Acid rain can damage trees and aquatic life. It washes important minerals, such as magnesium and calcium, out of the soil. As the acid rain runs through the soil it also washes out aluminum ions. The aluminum runs into rivers and lakes. Aluminum is very toxic to fish. Acid rain reduce the pH of many lakes killing fish. Fish die when the pH of the water drops below 4.5. Some acidic lakes and rivers contain hardly any fish.

B. Acid rain causes enormous damage to stone structure, paints and metals.

It can also damage buildings. The acid reacts with carbonates in the limestone. The limestone dissolves and the stone gradually crumbles away.

C. Sulfur dioxide damages living things. Humans who breathe in a lot of sulfur dioxide over a long period of time have an increased risk of suffering from colds, bronchitis and asthma. Sulfur dioxide can damage plant leaves and may kill the plant.

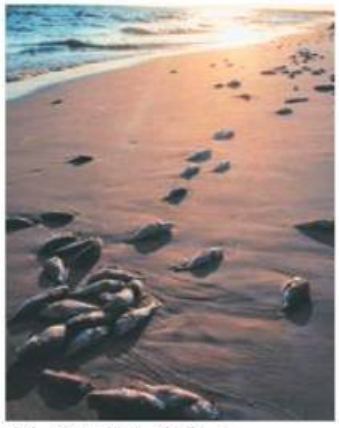


Fig. 37 Fish die in rivers or lakes when the pH of water is less than 4.5

1.3. Reducing the effects of acid rain

When acid rain falls to the ground, some of the acid is neutralized in the soil, and only the water that runs directly into streams and rivers is significantly acidic. Some soils–particularly those formed from limestone rock–have a large capacity to neutralize the acid. In other areas streams and lakes have become too acidic to support life.

What to do about acid rain?

It is quite difficult to protect a lake or stream from the effects of acid precipitation. In a few lakes, scientists have tried to reverse the effects of acid rain by adding crushed limestone to the water; but even repeated applications do not restore a lake to the level of quality it maintained before acidification. In the long run, the only way to stop the damage done by acid rain is to cut it off at its sources.

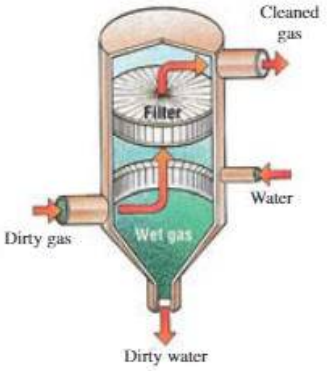


Fig. 38 As a result of using scrubbers, placed on stationary sources of pollution, our air quality is improving.

Cleaning up emissions

Sulfur dioxide, given off when fossil fuels are burned, is a major contributor to acid rain. There are two ways in which levels can be reduced. Sulfur impurities can be removed from coal before it is burned, and desulfurization equipment or scrubbers can be installed in factory and power plant smokestacks. Sulfur dioxide can be taken out using such scrubbers.

Fig. 39 A tree showing decline due to acid rain and air pollution.

Fig. 40 An acidic lake can often be saved by neutralizing the acid with basic substances such as lime.

2 Antacids

Emotional stress or overeating cause the stomach to make too much acid. This condition, known as hyperacidity, causes sharp pains commonly called heartburn. An antacid can be used to relieve these symptoms. Remember that the pH of stomach acid, which is mostly hydrochloric acid, is about 2.5.

Remark

If the stomach secretes too much hydrochloric acid over a long period of time, part of the stomach wall is digested creating an ulcer.

2.1. The Neutralizing Power of Antacids

There are many brands of antacids, which function using a variety of compounds. The active ingredients are often carbonates, bicarbonates or hydroxides.

Activity 1

Materials:

• White vinegar • Several commercial antacids • Mortar and pestle •Phenolphthalein • 3 beakers (250 mL) • Water • Dropper • Spatula • Glass rod

Antacids are anti or against acids.

Antacids = Anti-Acids = Bases

Procedure:

- Grind each antacid tablet (use two or three different brands) and put each in a beaker containing about 10 mL of water.
- Try to dissolve some of the antacid powder then add 2 drops of phenolphthalein in each beaker.
- Start adding vinegar drop by drop to the content of each beaker. Keep count of the drops added until the color first changes.

Fig. 41 Antacids are used to combat acid indigestion.

Analysis:

1. What does the change in color indicate?
2. What other signs indicate that a chemical reaction has taken place?
3. Do all antacids have the same neutralizing effect? Relate the number of drops of vinegar to the effect of the antacid.

Conclusion

When the hydrochloric acid in the stomach gets out of balance, sharp pains result. These may be relieved by doses of mild bases. All antacids are bases.

As bases, antacids neutralize the excess stomach acid.

2.2. Side Effects of Antacids

Like all medicines, antacids are not without side effects. Overuse of antacids might upset the delicate acid-base balance in the blood and leads to a condition called alkalosis.

Some antacids containing aluminum ions may deplete the body from essential phosphate ions through the formation of insoluble aluminum phosphate $AlPO_4$.

Table 1: Common Antacids

Brand	Active Ingredients
Tums	$CaCO_3$ (calcium carbonate), $MgCO_3$ (magnesium carbonate), and $Mg_2Si_3O_8$ (magnesium trisilicate)
Maalox	suspension of $Mg(OH)_2$ (magnesium hydroxide) and $Al(OH)_3$ (aluminum hydroxide) in water
Rolaids	$AlNa(OH)_2CO_3$ (aluminum sodium dihydroxycarbonate)
Sodium-Free Rolaids	$CaCO_3$ (calcium carbonate) and $Mg(OH)_2$ (magnesium hydroxide)
Alka-Seltzer	$Ca(H_2PO_4)_2$ (calcium dihydrogen phosphate), $NaHCO_3$ (sodium bicarbonate), citric acid, and aspirin

Sodium hydrogen carbonate ($NaHCO_3$) or common baking soda is an effective and inexpensive antacid for occasional use. It neutralizes hydrochloric acid in the stomach

$HCl + NaHCO_3 \rightarrow NaCl + H_2O + CO_2$

However, because it contains sodium, it is not recommended for people with high blood pressure.

3 Fertilizers in Agriculture

Gardening and farming require specific conditions of the soil for a healthy growth of plants.

Some of the elements, that are necessary for the quality of the crop, may be lost with ground water or due to acid rain. In order to maintain a certain composition of these elements in the soil, farmers use some of the following remedies.

3.1. Chemical Fertilization

A fertilizer is a natural or synthetic chemical substance or mixture used to enrich the soil so as to promote plant growth. Plants require large amounts of nitrogen, phosphorous and potassium. These three elements are the most common constituents of manufactured fertilizers.

Nitrogen, for example, can be supplied in the form of urea, nitrates and ammonium compounds.

Of the required nutrients, hydrogen, oxygen and carbon are supplied by air and water.

The elements, calcium, sulfur and iron are necessary nutrients that usually are present in soil.

Many fertilizers used since ancient times contain one or more of these elements (N, K, P) which are important to the soil.

For example, manure contains nitrogen, bones contain large quantities of phosphorous, while wood ash contains appreciable quantities of potassium.

Fig. 42 To ensure quality and good yield fertilizer is added to provide the necessary nutrients for plant.

3.2. pH Balance in Soil

The pH of the soil affects the health of the plant and its ability to produce fruit or blossoms. To measure the pH of soil you cannot just add universal indicator to a mixture of soil and water, because the color of soil muddles the result.

Activity 2

Materials:

• 2 Test tubes • Filter paper • Stopper • Distilled water • pH paper • Spatula • Funnel • Soil sample (from garden, a plant pot or from other locations).

Procedure:

- Put about 2 spatulas of the soil sample in a test tube. Add about 10 mL of distilled water; stopper and shake the tube.
- Filter the mixture and collect the filtrate in a glass test tube.
- Use the pH paper to determine the pH of the filtrate.
- Repeat the above procedure using other soil samples obtained from different locations.

Fig. 43 Liming of an acidic soil.

Analysis:

- Do all soil samples have the same pH?

Conclusion

Soil can be acidic, basic or neutral depending on its composition.

To maintain the pH balance of the soil, several things can be done:

1. If the soil is too acidic, lime (CaO) is often added. Lime dissolves in water to form calcium hydroxide $Ca(OH)_2$, which neutralizes excess acid in the soil.

   Wood ashes are also used to neutralize the excess acid. They contain sodium hydroxide and potassium hydroxide.

2. If the soil is too basic, different materials can be added. Sawdust and leaves when mixed with soil will slowly rot and produce carbon dioxide that dissolves in water in the soil to form carbonic acid, which neutralizes the excess base.

Table 2: Soil pH for Plant Growth

Conditions	pH	Group
High acid	4–5	Blueberries, cranberries, ferns, orchids, holly trees
Acid	5–6	Most berries and shrubs, dogwood, hemlock, spruce
About neutral	6–8	Most vegetables, flowers, trees, and grass
Basic	8–9	Hay and soybeans

3.3. Composting

Organic matter is the source of the soil's fertility. It provides the nutrients plants need to grow. So why not put wastes made of organic matter back into the soil?

That is exactly what many people are now doing by practicing composting.

The simplest way to compost is to layer different kinds of organic material into a mound (compost pile). The pile is kept moist and turned occasionally.

After a few weeks it changes into a fertilizer that can be added to garden soil and help plants grow.

Glossary

Compost: mixture of decomposing vegetable refuse, manure, and plants used as fertilizer and soil conditioner.

3.4. Eutrophication

Fertilizers used to increase the growth of crops also increase the growth of algae in surface waters. This increased water fertility which causes accelerated algae and water-plant growth, is called eutrophication.

Most often increased amount of phosphorous are the cause of eutrophication, but nitrogen and other nutrients can also contribute to the problem.

Eutrophication causes a decrease in the amount of oxygen in water thus damaging aquatic life in lakes and rivers. In some cases, certain algae also poison drinking water and livestock.

Unnecessary pollution should be avoided by wise use of fertilizers.

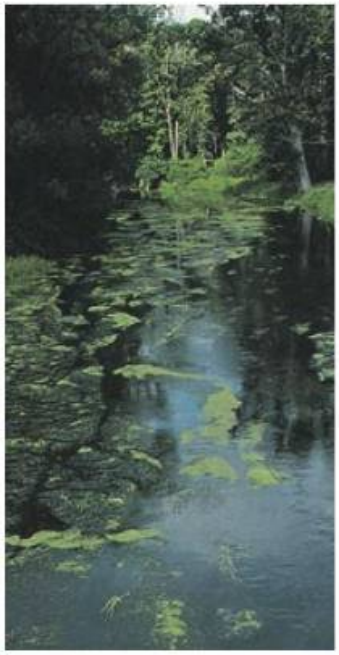


Fig. 44 The excess growth of algae in this stream indicates a high level of nutrients. The nutrients are supplied by both human and animal wastes upstream.

Chapter Review

- Acid rain refers to rain with pH less than 5.0 - 5.6
- The major sources of chemicals that produce acid rain are human activities.
- Acid rain can damage trees and aquatic life. It washes important minerals from the soil and reduces the pH of many lakes.
- Removing sulfur impurities from fuels and installing scrubbers in factory and power plant smokestacks help reduce acid rain.
- All antacids are bases. As bases, they neutralize the excess stomach acid.
- Overuse of antacids might upset the delicate acid-base balance in the blood and leads to a condition called alkalosis.
- A fertilizer is a natural or synthetic chemical substance or mixture used to enrich soil so as to promote plant growth.
- Many fertilizers used contain one or more of these elements (K, N, P) which are important to the soil.
- The pH of the soil affects the health of the plant and its ability to produce fruit or blossom.
- Compost is a mixture of decomposing vegetable refuse, manure and plants used as fertilizer.

Questions and Exercises

1. Explain why lakes in limestone areas are much less affected by acid rain.

2. Visit a local nursery or garden center. Ask how gardeners determine the pH of soil before planting flowers or shrubs. How can the pH of soil be changed?

3. Acid rain harms marble and limestone sculptures. Conduct a research to explain the effect of acid rain on some monuments.

4. Test the acidity of soil in different areas such as plant pots and gardens, then do a research to determine the effect of the soil acidity on healthy plant growth.

5. Hydrochloric acid in the stomach is important to the process of chemical digestion. However, too much acid in the stomach can be harmful. Use library references to find out how too much stomach acid can cause ulcer or other medical problems.

   How do antacids work to reduce the amount of acid in the stomach?

6. A soil test indicates that the pH of the soil in a field is 4.8. To neutralize the soil, would you add a substance containing H_3PO_4 or one containing $Ca(OH)_2$? Explain your answer.

2100 L.P.

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