Excellence in Chemistry

Senior Secondary 1

Teacher's Guide

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Introduction

The purpose of the curriculum

The general objectives of the curriculum are to enable students to:

- develop an interest in the subject of chemistry
- acquire basic theoretical and practical knowledge and skills in chemistry
- develop an interest in science, technology and mathematics
- acquire basic STM knowledge and skills
- be positioned to take advantage of the numerous career opportunities offered by chemistry
- be adequately prepared for further studies in chemistry.

The goals

The goals of the reviewed chemistry curriculum ensure that the teaching of chemistry will:

- facilitate a smooth transition in the use of scientific concepts and techniques acquired in the new Basic Science &Technology curriculum with chemistry
- provide students with the basic knowledge in chemical concepts and principles through efficient selection of contents and sequencing
- show chemistry and its inter-relationship with other subjects
- show chemistry and its link with industry, everyday life activities and hazards
- provide a course that is complete for students not proceeding to higher education, while at the same time providing a reasonably adequate foundation for a post-secondary school chemistry course.

Time allocation

To cover this curriculum, the recommended weekly time allocation is 120 minutes each. Students need to do regular revision at home in order to cope with the content and new terminology.

The role of the teacher

One of the principle duties of a Chemistry teacher is to prepare and present good lessons to his or her students. The teacher has to:

- be as well informed as possible on the scheme of work of the subject
- know the aims and objectives of each topic
- select appropriate content materials
- decide on the best methods of presentation such as slide shows, workstations, videos, discussion groups, worksheets, question–answer sessions, debate, and experiments
- gather equipment and other resources required for the activities
- keep informed about new developments and news in chemistry in Nigeria and the rest of the world
- arrange outings and guest speakers from time to time.

To be effective in presentation, the teacher must do a written/typed plan for each lesson. This must include aims, objectives, resources, time frames, content for the lesson, activities, homework, assessment, and ideas and additional worksheets to cater for students requiring extension or learning support (remedial).

Prepare each topic in advance. Many teachers go into the classroom inadequately prepared. It is your responsibility as a Chemistry teacher to actively involve your students in the learning process. It is a proven fact that students learn far more by doing than by listening.

You should endeavour to apply the scientific method throughout. Science involves being curious and asking questions. Wherever possible ask questions to engage the students and to encourage independent thought processes. Start your lessons by asking the students to write down answers to questions related to your lesson (approximately five). This will settle them into the lesson. You can use different types of questions in your lessons:

- for enabling you to determine prior knowledge on the topic (diagnostic)
- for consolidation of challenging concepts during the lesson
- for stimulation of interest in the subject
- for concluding the lesson.

This will assist you to find out whether students have understood the concepts and terminology in the lesson. It will also highlight any areas that they need to revise at home or for you to revisit in the next lesson.

Teachers must ensure that they do not appear to have favourites in the class, so devise a system to ensure that you ask questions fairly, but be careful not to embarrass weak students if they cannot answer questions.

How to use the book

The purpose of this *Teacher's Guide* is to assist you to use the *Student's Book* and be more thoroughly prepared so that your teaching is be more meaningful to your students. This book supports a hands-on approach and lays a solid foundation for SS2 and SS3.

You need to be familiar with the key features of the *Student's Book*.

The book is divided into 10 topics. Each topic is structured in the following way:

- performance objectives required by the curriculum
- content required by the curriculum
- activities to be completed individually, with a partner, in groups or as a class
- summary of the topic
- key words, which are essential vocabulary for the topic
- revision questions for revision of the topic.

How to use the scheme of work

A scheme of work is defined as the part of the curriculum that a teacher will be required to teach in any particular subject. Its primary function is to provide an outline of the subject matter and its content, and to indicate how much work a student should cover in any particular class. A scheme of work allows teachers to clarify their thinking about a subject, and to plan and develop particular curriculum experiences that they believe may require more time and attention when preparing lessons. The criteria all teachers should bear in mind when planning a scheme of work are continuity in learning and progression of experience. You can add your own notes to the scheme of work provided on pages viii to x.

The scheme of work is sequential. The sequence of the scheme of work is aligned with the textbook. Do not be tempted to jump around. Rather spend time carefully planning the term to ensure that you adhere to the scheme of work.

The year is divided into 3 terms. Each term is divided into 13 weeks. There are 4 topics in Term 1, 3 topics in Term 2 and 3 topics in Term 3. The end of term allows time for revision and an examination. This time frame may vary depending on the planning of your particular school.

The right-hand column gives the number of suggested lessons for each topic. This has been divided according to the content of the topic. These vary from 2 to 5 lessons per topic.

The first lesson is usually an introduction to the topic. Make an effort to make this lesson exciting and informative. You should always explain the meaning of the topic in this lesson, for example: What is chemistry?

How can we use chemistry in daily life? What is the scientific method?

The last lesson is allocated to revision. In this lesson you can give the class a revision worksheet, a test or design a fun activity, such as a game or a quiz, to consolidate the topic. Students can also do their own revision by making mind maps, concept maps or other types of summaries. They can also set tests for each other.

It is important to note that these are a suggested number of lessons for the topic. The amount will vary according to the ability of the students in your class and their prior knowledge. Your management of the class will have an enormous influence on your ability to adhere to the time frames. Focus on effective discipline strategies. You will have less discipline issues if you are: punctual, well prepared, follow a plan (write this on the board at the start of the lesson), keep your word (do not make empty threats), consistently adhere to rules, especially rules related to laboratory safety, and strive to make Chemistry an exciting subject.

A teacher of Chemistry is a professional instructor who facilitates, promotes and influences students to achieve the outcomes of the scheme of work. It is the wish of the authors that the students will, at the end of each course in the series (SS1, SS2 and SS3) attain a level of proficiency in chemistry that will equip them for future studies in this field.

Safety information

Safety data

Safety is of great importance in experiments. Many of the chemicals and other equipment used in a science laboratory can be hazardous. All laboratories should have a set of material safety data sheets (MSDS) for the chemicals they stock. These can be obtained from the supplier of the chemicals.

Chemists use a set of symbols to inform the users of potential dangers. Study the internationally used hazard symbols below.

This symbol means that the chemical is highly flammable. It can catch fire easily and should not be left near an open flame. Methylated spirits is an example of a highly flammable chemical.

An oxidising substance contains oxygen that can cause other substances to burn more easily. Sodium chlorate releases oxygen when it reacts.

The symbol for toxic substances is the skull and crossbones because these substances can kill you. They must be handled with great care and only under the supervision of a teacher.

Corrosive substances can burn your skin and eyes, and can burn holes in your clothes. Always use safety glasses when working with these chemicals. Many acids are corrosive.

Some substances can cause your skin to turn red or to blister. Certain dry powders can make you cough. These substances are called irritants. They are less dangerous than corrosive materials, but should still be handled with care.

Some compounds may explode if they come into contact with a flame or heat. They may also explode due to friction or shock.

Laboratory safety rules

1. Conduct yourself in a responsible manner at all times in the laboratory. Never fool around in the laboratory. Horseplay, practical jokes and pranks are dangerous, and are prohibited.
2. You may not enter a laboratory or a chemical store room without the presence or permission of a teacher.
3. On entering a science laboratory, do not touch any equipment, chemicals or other materials in the laboratory area until you are instructed to do so.
4. Follow all written and verbal instructions carefully. Perform only those experiments authorised by your teacher. Unauthorised experiments are not allowed.
5. Do not eat, drink or chew gum in the laboratory. Do not use laboratory glassware as containers for food or water to drink.
6. You may not remove any apparatus or chemicals from the laboratory.
7. The laboratory should be well ventilated. Poisonous gases must be kept and used in a fume cupboard.
8. Always wear safety goggles in a laboratory when chemicals, heat or glassware are used.
9. Never leave an open flame without supervision.
10. Never smell, touch or taste chemicals unless your teacher instructs you to do so.
11. Never point the open mouth of a test tube in anyone's direction.
12. Never look into a container that is being heated.

13. Keep flames and flammable chemicals apart.
14. Keep electrical equipment away from water.
15. Dispose of all chemical waste properly. Never mix chemicals in sink drains. Sinks are to be used only for water. Never pour unused chemicals back into the reagent bottle. Check with your teacher for disposal of chemicals and solutions.
16. Keep your hands away from your face, eyes, mouth and body while using chemicals or lab equipment. Always wash your hands with soap and water after performing any experiment.
17. Notify the teacher immediately in case of any accident or breakage.
18. If a chemical should splash into your eye(s) or onto your skin, immediately flush with running water for at least 20 minutes. Notify your teacher immediately.

Scheme of work

Table 1: Chemistry teaching schemes of work for SS1

Term	Week	Theme	Topic	Performance objectives (students should be able to:)	Content	SB page
Term 1	1–2	Chemistry and industry	1. Chemical industries	1.1 Identify chemical industries in their locality 1.2 Explain how these chemical industries have influenced their lives and Nigeria's economy 1.3 Describe the environmental problems created by the chemical industries 1.4 Suggest some solutions to solving some of these environmental problems	1. Types of chemical industries 2. Importance of chemical industries: • to the individual • to the nation 3. Excursion to chemical industries	1
	3–4	The chemical world	2. Introduction to chemistry	2.1 Define chemistry 2.2 List career prospects in chemistry 2.3 Explain the application of chemistry 2.4 Describe the adverse effects of chemicals 2.5 Explain how scientists carry out investigations – the scientific method	1. The meaning of chemistry 2. Career prospects tied to chemistry 3. Application (hospital, military, teaching, chemical and petrochemical industries, space science, agriculture, etc.) 4. Adverse effects of chemicals, drug abuse, poisoning, corrosion, pollution 5. Scientific method	14
	5–7		3. The particulate nature of matter	3.1 Distinguish between physical and chemical changes 3.2 Distinguish between atoms and molecules 3.3 Describe how the particles are arranged in the atom 3.4 Define: • atomic number • mass number • isotopes 3.5 Calculate the relative atomic masses of atoms	1. Physical and chemical changes 2. Atoms and molecules 3. Dalton's atomic theory 4. Constituents of : • atoms • protons • neutrons • electrons 5. Arrangement of protons around the nucleus 6. Atomic number, mass number and isotopes 7. Relative atomic masses based on the C-14 isotope	25
	8–10		4. Symbols, formulae and equations	4.1 State the symbols of the first 20 elements and other common elements 4.2 Distinguish between elements, compounds and mixtures 4.3 Write chemical formulae and chemical equations 4.4 Calculate the empirical and molecular formulae of compounds 4.5 Illustrate that matter is neither created nor destroyed 4.6 State and illustrate the laws of constant composition and multiple proportions	1. Chemical symbols of elements and their valencies 2. Empirical and molecular formulae 3. The Law of Conservation of Matter 4. The Law of Constant Composition 5. The Law of Multiple Proportions 6. Chemical equations	41
	11	Revision				
	12–13	Examinations				

Term	Week	Theme	Topic	Performance objectives (students should be able to:)	Content	SB page
Term 2	1–5	The chemical world (continued)	5. Chemical combination	5.1 Identify the first 20 elements of the Periodic Table 5.2 Write the electronic configuration of the atoms of the first 20 elements 5.3 Explain the concept of atomic numbers 5.4 Arrange the elements in the Periodic Table based on their atomic numbers 5.5 Differentiate between various types of chemical bonding 5.6 Name compounds by their conventional and IUPAC names 5.7 Distinguish between solid, liquid and gaseous states of matter 5.8 Discuss the kinetic theory and its applications	1. Periodic Table (first 20 elements) 2. Electronic configuration of atoms 3. Types of bonds: • strong bonds, such as electrovalent (ionic), covalent, coordinate covalent (dative), metallic bonds • weak bonds, such as hydrogen bonds and Van der Waal's forces 4. Systems of naming compounds: • conventional • IUPAC • (any of these two systems is acceptable at this level) 5. States of matter • solid • liquid • gas 6. The Kinetic Theory and change of state	66
	6–8		6. Gas laws	6.1 Demonstrate diffusion of gases 6.2 State the relationship between rate of diffusion and density of gas/vapour 6.3 Show how heat affects the volume of a given mass of gas 6.4 Explain the Kelvin scale of temperature and its relationship to the Celsius scale 6.5 Explain the effect of pressure on the volume of a gas 6.6 Explain the effect of temperature and pressure on the volume of gas 6.7 Show that $PV = nRT$ is the general gas equation	1. Boyle's Law 2. Charles' Law 3. General gas equation 4. Gay-Lussac's Law 5. Avogadro's Law 6. Ideal gas equation 7. Graham's Law 8. Molar volume of gases 9. Avogadro number and the mole concept 10. Calculations based on gas laws	92
	9–10	Chemistry and the environment	7. Standard separation techniques for mixtures	7.1 State the different standard methods of separating mixtures and their individual applications 7.2 Manipulate different apparatus for separation techniques 7.3 Draw separation technique apparatus 7.4 State the criteria for purity 7.5 Distinguish between pure and impure substances	1. Classification of substances 2. Filtration, evaporation, decantation, floatation, frostation 3. Crystalisation and fractional crystalisation 4. Distillation and fractional distillation 5. Precipitation 6. Magnetism 7. Chromatography 8. Sublimation 9. Pure and impure substances	111
	11	Revision				
	12–13	Examinations				

Term	Week	Theme	Topic	Performance objectives (students should be able to:)	Content	SB page
Term 3	1–3	Chemistry and the environment (continued)	8. Acids, bases and salts	8.1 Define acids, bases and salts 8.2 Identify acids and bases 8.3 Describe the nature of protons in an aqueous solution 8.4 Explain neutralisation reactions 8.5 Explain how an acid–base indicator works 8.6 Use pH as a scale and discuss the importance of the pH value 8.7 Identify and prepare slats (normal, acidic and basic) 8.8 State properties of salts 8.9 State the rules of solubility in water	1. Characteristics, preparations, reactions and uses of acids, bases and salts 2. Relative acidity and alkalinity (the pH scale) 3. Deliquescent, efflorescent and hydroscopic substances 4. Solubility of salts in water	131
	4–5		9. Water	9.1 State sources of water 9.2 State the properties of water 9.3 Describe the laboratory preparation of water 9.4 Distinguish between soft and hard water 9.5 Define pollution and list some water pollutants 9.6 State the uses of water 9.7 Describe the procedure for the laboratory preparation of water	1. Sources of water 2. Types of water (soft and hard) 3. Water pollutants 4. Uses of water 5. Laboratory preparation of water	161
	6–8	The chemistry of life	10. Carbon and its compounds	10.1 Identify various substances in and around us that contain carbon 10.2 Describe the unique characteristics of carbon as an element 10.3 Explain the relationship between the structure of carbon and the existence of many natural and synthetic carbon-containing compounds 10.4 Infer that a large percentage of world energy needs depend on carbon-containing compounds like coal, coke and petroleum 10.5 Define the term 'allotrope' 10.6 Show that carbon forms two types of oxide, both of which are important economically 10.7 Identify carbon(IV) oxide	1. Carbon • structure of carbon 2. Allotropes of carbon: • charcoal graphite and diamond • structure and properties of the allotropes • the combustion of carbon allotropes 3. Coal: • different types • industrial distillation of coal • uses and products 4. Coke: • classification and uses • carbon dioxide (carbon(IV) oxide) and carbon monoxide (carbon(II) oxide) 5. Synthetic gases: • manufacture and carbon uses • carbonic acid (trioxicarbonate(IV) acid) • any carbonate (trioxicarbonate(IV)) salt 6. Hydrocarbon and its main classes 7. Crude oil and natural gas 8. Importance of hydrocarbons	179
	9/10	All practicals				
	11	Revision				
	12–13	Examinations				

THEME 1 Chemistry and industry

Topic 1: Chemical industries

Performance objectives

1.1 Identify chemical industries in their locality
1.2 Explain how these chemical industries have influenced their lives and Nigeria's economy
1.3 Describe the environmental problems created by the chemical industries
1.4 Suggest some solutions to solving some of these environmental problems

Introduction

This topic covers types of chemical industries, the importance of these to the individual and to the nation. An excursion to chemical industries is also organised.

Activity 1.1: Chemical industries in the locality INDIVIDUAL (SB p.4)

Resources

Library, the Internet

Guidelines

Students must research the questions on their own and share their answers with the class. Use pictures of some local industries to guide students to identify chemical industries in Nigeria.

Answers

Check the answers to make sure that they reflect understanding of the industry.

Activity 1.2: Identify careers in the chemical industries INDIVIDUAL (SB p.4)

Resources

Library, the Internet

Guidelines

Students must identify a chemistry-related career and do research in the library or on the Internet to find out what it entails OR they need to identify someone in their environment that has a chemistry-related career and ask them about their job and how chemistry is used in this job.

Guide students on how to present their report.

Activity 1.3: The importance of the chemical industries INDIVIDUAL (SB p.9)

Guidelines

Initiate and guide discussion on the economic importance of the chemical industries.

Answers

1. Commodity or basic chemicals: hydrochloric acid, phosphoric acid, sulphuric acid, ammonia, sodium hydroxide, nitrogen and oxygen
   Fine chemicals: drugs, food additives and fragrances
   Speciality chemicals: adhesives, detergents and soaps, dyestuffs and pigments, fertilisers, pesticides and herbicides, pharmaceuticals, plastics
2. a) Drugs and medicines prevent and cure diseases.
   Fertilisers and pesticides increase crop yield and food is more available.
   Plastics, synthetic and new materials improve the quality of life.
   People are employed and receive wages and other benefits.
   b) Foreign currency drives the economy.

Raw materials can be exported or used to manufacture products.
Oil and gas are used to generate electricity.
Foreign earning can help to improve infrastructure.

3. Student's own ideas and opinions.

Activity 1.4: Field trip to a chemical industry

INDIVIDUAL (SB p.11)

Guidelines

Organise the necessary permission, transport and accommodation (if required) to visit the chosen factory.

Remind the students that it is a privilege to visit a working factory and that they should behave accordingly. All industrial factories are dangerous places, with lots of machinery that must only be operated by skilled persons. Student must:

- not touch anything unless instructed to
- adhere to the safety rules of the factory and instructions of the people in charge
- listen to all the information given by the experts
- ask questions and make notes of all the processes in the manufacturing process.

Guide the students to:

- observe the process going on in the industry
- observe the various ways the industry degrades the environment
- suggest ways of reducing environmental problems.

Answers

The students should be able to answer the questions provided for the industry they have visited.

Revision questions: Answers

(SB p. 13)

1. Kaduna, Warri and Port Harcourt
2. Iron and steel is very important for the development of infrastructure to boost the economy. It is needed for the construction of agricultural irrigation, farm mechanisation, new roads and bridges and housing developments.
3. A chemical industry is needed for the country's own sustainable development, to boost its economy and to improve the quality of life of its people.
4. Acids such as HCl, H_3PO_4 and H_2SO_4; alkalis such as NH_3 and NaOH; gases such as N_2 and O_2
5. Chemists developed drugs that are used in medicines; fertilisers and pesticides to increase crop yield; plastics and packaging to keep food fresh; new materials such as semiconductors used in cell phones and computers
6. The chemical industry employs many workers; their wages support their families; they have benefits, such as health and medical care, retirement and insurance packages; they educate and train their workers.
7. a) Rotting waste can cause health problems and diseases to humans and animals and pollute the environment. Waste looks ugly and pollutes the air, soil and water. Broken glass, rusty metal and plastic can be dangerous and cause injuries to humans and animals. Waste can block sewage and water drains.
   b) We should reuse waste products, for example, plastic bags and containers and glass bottles and jars. We should recover, sort and deliver materials that can be recycled to institutions that deal with waste recycling.
   c) Glass, paper, plastics and metal can be recycled.
8. It is expensive to collect waste, build landfill sites and dump waste.
   Landfill sites use up valuable land.
   The raw materials from each recycled item can be reprocessed into new products.
   Recycling can be a source of income for many people.
   It helps to keep the environment clean.
   It saves resources, because new raw materials do not have to be mined or produced.
9. Build chemical plants in industrial areas on the outskirts of towns.
   The government must provide and enforce clear policies and legislation.
   The chemical industry must care for the health and safety of its workers, take responsibility for the environmental impact of the product for its full lifespan and communicate hazards to its workers and the public.
   Consumers must read and understand cautionary labels, use chemicals as directed and dispose of waste chemicals safely.

How are you doing?

Take this opportunity to ask learners if there is anything that they do not understand. You can check their understanding by asking them some questions about the information covered in the unit. Explain anything that learners do not understand.

Key words

analytical chemists – people who examine the composition, structure and characteristics of materials by examining and identifying the various elements or compounds that make up the substances, as well as the processes and changes that they undergo

beneficiation – a process that improves a material or mineral to produce a higher grade product

effluent – sewage or liquid waste

exploitation (of oil) – the development of an oil well to extract the oil for profit

exploration (of oil) – the search by geologists and physicists for hydrocarbon deposits beneath the Earth's surface

industrial chemists – people who work on new ideas and then design, test and build prototypes of these products

infrastructure – the basic physical and organisational structures and facilities (such as buildings, roads, power supplies) needed for the operation of a country

product stewardship – taking responsibility of a product and reducing its impact on the environment and our health

quality control chemists – people who prepare and test samples from all phases of manufacturing or other handling processes

saponification – the hydrolysis process that is used to manufacture soap from fatty acids and a strong base

sinter – the process of compacting and forming a solid mass of materials by heating it to below the melting point

Checklist for Self-evaluation

Theme 1 Topic 1

EVALUATION GUIDE: Student should be able to:

	Criteria	4	3	2	1	Comments
1	Name the chemical industries in Nigeria					
2	State the importance of the industries to: • individuals • nation					
3	State the effects of the industries on the environment					
4	Identify ways of solving some of the environmental problems					

Code for evaluation:			
4 – Very well	3 – Well	2 – Fairly well	1 – Not well at all

THEME 2 The chemical world

Topic 2: Introduction to chemistry
Performance objectives
2.1 Define chemistry **2.2** List career prospects in chemistry **2.3** Explain the application of chemistry **2.4** Describe the adverse effects of chemicals **2.5** Explain how scientists carry out investigations – the scientific method

Introduction

In this topic the students are introduced to chemistry. They will also identify career prospects in chemistry. Students should be able to explain the application of chemistry as well as the adverse effects of chemicals. Lastly, students should be able to explain how scientists carry out investigations by using the scientific method.

Activity 2.1: Careers tied to chemistry

GROUP (SB p.16)

Resources

Library, the Internet

Guidelines

Students must identify a chemistry-related career and do research in the library or on the Internet to find out what it entails OR they need to identify someone in their environment that has a chemistry-related career and ask them about their job and how chemistry is used in this job.

Encourage students to participate in the class discussion by asking and answering questions.

Use pictures of some chemical industries and laboratories to guide students to identify various careers in the chemical industry.

Guide students on how to present their report.

Students should be able to:

- define chemistry; and
- list four careers that are linked to chemistry.

Answers

1. Learners should select one career and research it.
2. Feedback should be given to the class.
3. A variety of careers tied to chemistry should be covered by the different groups.

Activity 2.2: Applications of chemistry

INDIVIDUAL (SB p.19)

Guidelines

Use posters and charts to guide class discussion of the applications of chemistry.

Answers

1. Hospital: Production of medicines, purifying drinking water, producing cleaning agents, etc.
2. Forensics: Analyse blood, investigate physical and chemical properties of substances, solve crimes using forensic analysis, etc.
3. Industries: Invent new chemical products, produce toiletries, produce oil and petroleum, etc.

Activity 2.3: Adverse effects of chemicals
INDIVIDUAL (SB p.21)

Guidelines

Use posters and pamphlets from clinics or hospitals, or pictures from magazines to guide a discussion on the adverse effects of chemicals. Students can visit their local library or use the Internet to research the cause and effect of various chemicals. Encourage the students to talk to family members, or members of the community, who are involved in these areas, such as ministers or youth councillors.

Answers

1. Drug abuse: People who abuse drugs run the risk of heart attacks, strokes, display violent behaviour, panic attacks, psychosis and mood swings. The sleep patterns of drug abusers are also affected.
2. Poisoning: Poison can interfere with the normal functions of a body. The poisoning could be severe if a person is exposed to toxic substances, such as cyanide, or it can damage body tissue if exposed to strong acids.
3. Corrosion: When strong acids or bases are inhaled, they can cause immediate damage to the respiratory tract. When corrosive substances come into contact with living tissue, they can cause chemical burns. Corrosion also causes things to break.
4. Pollution: Chemical waste containing poisonous chemicals can contaminate vegetation, surface water and ground water supplies. Some of the chemicals find their way into other organisms that eat the plants or drink the water that are contaminated. People that are extensively exposed to air pollution suffer from headaches, dizziness, irritation of the eyes and nose, allergies and respiratory disorders.

Activity 2.4: Scientific method
GROUP (SB p.23)

Guidelines

Take students to visit local chemical industries, such as paints, tie and dye, vegetable oil, and petrochemical industries.

Explain the scientific methods of enquiry using specific examples.

Organise the necessary permission, transport and accommodation (if required) to visit the chosen factory.

Remind the students that it is a privilege to visit a working factory and that they should behave accordingly. All industrial factories are dangerous places, with lots of machinery that must only be operated by skilled persons. Student must:

- not touch anything unless instructed to
- adhere to the safety rules of the factory and instructions of the people in charge
- listen to all the information given by the experts
- ask questions and make notes of all the processes in the manufacturing process.

Guide a class discussion on the various scientific methods used to make observations and conduct experiments

Answers

1. C
2. D
3. C
4. B
5. D
6. C
7. D
8. D

Revision questions: Answers

(SB p. 24)

1. Aim, apparatus, method, results, conclusion
2. 1. Observe the world.
   2. Identify an answerable question.
   3. Formulate a hypothesis.
   4. Design an experiment.
   5. Identify and control variables.
   6. Collect data accurately.
   7. Interpret data.
   8. Verify results.
   9. Draw a conclusion.
   10. Formulate results.
3. Chemistry is a science that studies the composition of substances and the ways in which their properties are related to their composition.
4. Teacher, chemical engineer, pharmaceutical researcher, forensic scientist
5. a) Chemistry is used in the military to help develop new weapons and protective equipment.
   b) Chemists analyse samples of food and drinks routinely to ensure that standards are met. Chemists in the oil and petroleum industry work with crude oil and the products derived from it.
   c) Chemists help develop new chemicals to increase crop production and yield, defend against pests, and protect the environment.
   d) A chemist can help to identify the compositions of stars and to identify soil and rocks from planets and moons. Research in space also helps us to better understand our own planet.
6. a) 'Design an experiment' means to test your hypothesis and use a procedure that will enable a fair test.
   b) 'Verify results' means conduct more experiments to make sure your results can be repeated.
   c) 'Draw a conclusion' means to recognise, analyse and evaluate alternative explanations for the same set of observations. Write a conclusion for your experiment that confirms your hypothesis, or adjust your hypothesis to fit the results.
7.

Column A	Column B
Scientific method	A logical approach to the solution of scientific problems
Observation	Information obtained through one's senses
Independent variable	Variable that one changes during an experiment
Hypothesis	A proposed explanation for an observation
Experiment	A means to test a hypothesis
Dependent variable	Variable is observed during an experiment

How are you doing?

Take this opportunity to ask learners if there is anything that they do not understand. You can check their understanding by asking them some questions about the information covered in the unit. Explain anything that learners do not understand.

Key words

chemistry – the study of the composition of substances and the ways in which their properties are related to their composition

corrosive – tending to cause corrosion (the eating away and destruction of materials, including living tissue)

crude oil – a mixture of hydrocarbons that exists as a liquid in natural underground reservoirs and remains a liquid when brought to the surface

experiment – a scientific procedure undertaken to make a discovery, test a hypothesis or demonstrate a known fact

law – a theory that was accepted and that has worked positively for a very long time

matter – all substances and materials from which the physical universe is made

model – a real or mental picture of a concept in terms of what we know

out of the box (thinking) – thinking of things from a different perspective

poison – a substance that can cause disturbances (harm) to organisms

prognosis (plural: prognoses) – what will happen in a medical condition

scientific method – scientific and systematic way for scientists to do their work when working in science

theory – a hypothesis that was proved correct after different scientists conducted many experiments

toxicity – how toxic or poisonous something is

Checklist for Self-evaluation

Theme 2 Topic 2

EVALUATION GUIDE: Student should be able to:

	Criteria	4	3	2	1	Comments
1	Define chemistry					
2	List career prospects in chemistry					
3	Explain the application of chemistry					
4	Describe the adverse effects of chemicals					
5	Explain how scientists carry out investigations – the scientific method					

Code for evaluation:			
4 – Very well	3 – Well	2 – Fairly well	1 – Not well at all

Topic 3: The particulate nature of matter

Performance objectives
3.1 Distinguish between physical and chemical changes **3.2** Distinguish between atoms and molecules **3.3** Describe how the particles are arranged in the atom **3.4** Define: • atomic number • mass number • isotopes **3.5** Calculate the relative atomic masses of atoms

Introduction

In this topic we discuss the particulate nature of matter. We distinguish between a physical and a chemical change. We will look at atoms as the building blocks of all matter and how atoms can combine to form different molecules. The atom is made up of sub-atomic particles, called protons, electrons and neutrons. The electrons are arranged in a specific way around the nucleus of an atom. We will also look at the meaning of atomic number, mass number and isotopes, and how all these relate to sub-atomic particles.

Experiment 3.1: Physical change

GROUP (SB p.26)

Resources:

Empty tin or glass beaker, ice cubes, tripod stand with gauze wire mat, heat source (such as a spirit burner or Bunsen burner), candle wax, small aluminium foil pie dishes, camphor balls (moth balls), matches, knife

Guidelines

This experiment can be used as a class test.

In this experiment the students will investigate non-permanent physical changes of state by heating solid candle wax and ice.

Show the class how their everyday experiences have examples of physical changes, such as burning a candle, which melts wax, or dissolving salt in water.

Make sure that you do not heat the wax to very high temperatures, which will vaporise the wax. The vapour can ignite. Stop heating the moth balls when the smell has filled the room.

Answers

1. Method 1 showed a physical change, because when the ice melted, it changed from a solid to a liquid and, when placed in a freezer, the water turned into a solid again.
   Method 2 showed a physical change, because the wax melted (it changed from a solid to a liquid when heated), but when it was cooled, it turned into a solid again.
   Method 3 showed a physical change, because the moth balls gradually vaporised.
   Method 4 showed a physical change, because the table salt dissolved in the water.
   In all of the methods there was a phase change.
2. Method 1: The change is non-permanent because the water froze again when it was placed in the freezer
   Method 2: The change is non-permanent, because after the melted wax solidified again, the wax is the same as it was at the start.
   Method 3: The change is permanent, because the moth ball reduced in size as it was heated.
   Method 4: The change is non-permanent, because, when the salt-water mixture was heated and all the water disappeared, the salt was is visible at the bottom of the beaker.

Experiment 3.2: Burning magnesium ribbon in air (oxygen) INDIVIDUAL (SB p.28)

Resources

Magnesium ribbon, sandpaper, tongs, Bunsen burner, porcelain dish

Guidelines

In this experiment students will see what happens when magnesium ribbon burns in air (oxygen).

Encourage a class discussion about the chemical change which took place during this experiment.

Students should be able to identify that a chemical change took place in the experiment.

Experiment 3.3: How to prepare chalk ($CaCO_3$) INDIVIDUAL (SB p.29)

Resources

Safety goggles, four beakers,100 ml graduated cylinder, glass stirring rod, funnel, filter paper, distilled water, 2 g calcium chloride, 1 g sodium carbonate

Guidelines

Students must be able to produce calcium carbonate (chalk) from aqueous solutions of calcium chloride and sodium carbonate.

Guide the students to observe: When the calcium chloride solution reacts with the sodium carbonate solution, a chemical change occurs. A white solid (calcium carbonate) is produced in the process. The calcium carbonate is separated from the water by means of filtration. The calcium carbonate remains on the filter paper while the water runs into the beaker.

Students should be able to identify chalk-making as a chemical change.

Activity 3.1: Physical and chemical change GROUP (SB p.30)

Guidelines

Students should be able to explain the difference between physical and chemical changes, with appropriate illustrations.

Guide a class discussion on the differences that the students identified during the activity.

Answers

1. A
2. D
3. No new substances are formed during a physical change. New substances are formed during a chemical change.
4. a) Physical
   b) Physical
   c) Chemical
   d) Chemical
   e) Chemical

Activity 3.2: Atoms and molecules INDIVIDUAL (SB p.32)

Guidelines

Guide the students in a class discussion of what atoms and molecules are, listing their differences.

Answers

1. a) Atoms are the basic building blocks of matter. Atoms are extremely small.
   b) When atoms combine, they form a molecule.
2. a) B
   b) A and C

Activity 3.3: A model of an atom INDIVIDUAL (SB p.35)

Resources

beads of different colours, dried lentils or dried peas, paper plates, glue, coloured pens, paper

Guidelines

Guide a class discussion on how the particles are arranged in the atom.

Students should be able to draw and describe the structure of the atom in writing.

Answers

Check that the students have correctly placed the beads based on the element they have chosen. Also check that they have the correct numbers of beads.

Activity 3.4: Constituents of atoms

INDIVIDUAL (SB p.35)

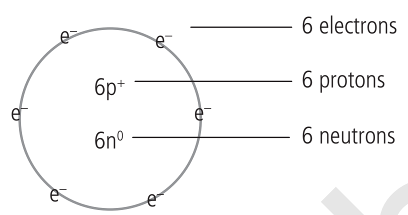
Guidelines

Students should be able to explain Dalton's Atomic Theory, and the different particles in an atom.

Guide a class discussion on the various particles in an atom.

Answers

1. Protons, neutrons and electrons
2. a) No charge (neutral)
   b) Negative
   c) Positive
3.



Activity 3.5: Arrangement of electrons around the nucleus

INDIVIDUAL (SB p.36)

Guidelines

This can be used as a class test.

Students should be able to discuss the arrangements of electrons in the atom, also known as electron configuration.

Guide a class discussion on electron configuration.

Answers

1. Electron configuration
2. Electrons on energy level 3 have <u>lower</u> energies than electrons in energy level 2.
3. a) Energy level 3 = 2(3)2 = 18 electrons
   b) Energy level 4 = 2(4)2 = 32 electrons
4. a) 1
   b) 2
   c) 2
   d) 3

Activity 3.6: Atomic number, mass number and isotopy

INDIVIDUAL (SB p.37)

Guidelines

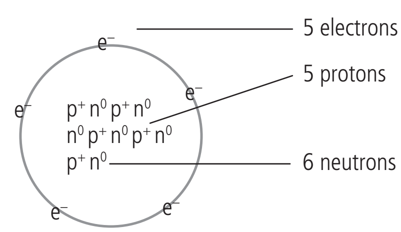
This can be used as a class test.

Students should be able to define atomic number, mass number and isotopes.

Guide a class discussion on the different definitions and formulae, using the examples in the SB.

Answers

1. A
2. B
3. a) Atomic number: The number of protons in the nucleus
   b) Mass number: The total number of protons plus neutrons makes up the total mass of the atom.
4. a) Negative
   b) Neutral (no charge)
   c) Positive
   d) Positive
   e) Neutral (no charge)
   f) Positive
5. a) Boron: 5 protons, 6 neutrons and 5 electrons
   b) Boron atom:



6. All the isotopes have the same number of protons and electrons but have different numbers of neutrons.
7.

Isotope	Symbol	Number of protons	Number of neutrons	Number of electrons
Uranium-235	$^{235}_{92}U$	92	143	92
Uranium-238	$^{238}_{92}U$	92	146	92

Activity 3.7: Relative atomic mass

INDIVIDUAL (SB p.38)

Guidelines

Students should be able to calculate the relevant molecular mass of a compound.

Guide the students to calculate the relative molecular mass of a compound, using the examples in the SB.

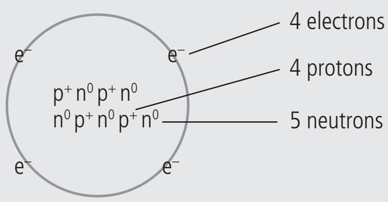
Answers

1. The relative atomic mass (A_r) is the ratio of the average mass per atom of an element to $\frac{1}{12}$ of the mass of a carbon-12 atom.
2. Relative atomic mass of uranium = $14 \times 17 = 238$
3. The relative atomic mass of the sample of bromine $= \frac{79 + 81}{2} = 80$
4. Relative atomic mass of copper
$= \frac{(62.9 \times 63) + (30.8 \times 65)}{100}$
$= 59.6$

Revision questions: Answers

(SB p. 39)

1. a) Chemical change
   b) Chemical change
   c) Physical change
   d) Chemical change
2. a) Melting
   b) Physical change. No new substances are formed. The substance undergoes a phase change.
   c) Energy is released during freezing.
   d) Chemical change. New substances are formed during process C.
3. a) C
   b) A
   c) B
   d) B
   e) C
4.



5. Dalton's Atomic Theory states that:
   – Elements are made of small particles, called atoms.
   – Atoms cannot be subdivided.
   – All atoms of an element are identical.
   – Atoms of different elements differ.
   – Atoms combine in whole-number ratios to form compounds.
   – Atoms combine in chemical reactions.
6. a) Positive or +11
   b) 12 units
   c) No charge
   d) 11 electrons
7. a) 2 shells
   b) 2 electrons
   c) 8 electrons
   d) No, because the first shell can only accommodate a maximum of two electrons and the second shell can accommodate a maximum of 8 electrons.
8.

No	Name	Mass number	Atomic number	Nucleons	Protons	Neutrons	Electrons
1	Magnesium	24	12	24	12	12	12
3	Oxygen	16	8	16	8	8	8
4	Sodium	23	11	23	11	12	11
5	Sulphur	32	16	32	16	16	16
6	Potassium	39	19	39	19	20	19

9. a) The relative atomic mass is the ratio of the average mass per atom of an element to $\frac{1}{12}$ of the mass of a carbon-12 atom.
   b) Relative atomic mass of magnesium = 24
      Relative atomic mass of hydrogen = 1

How are you doing?

Take this opportunity to ask learners if there is anything that they do not understand. You can check their understanding by asking them some questions about the information covered in the unit. Explain anything that learners do not understand.

Key words

aqueous solution – a solution in which water is the solvent; shown in chemical equations by appending '(aq)' after the relevant chemical formula

atomic number – the number of protons in one atom

chemical change – a change that involves the transformation of one or more substances into one or more different substances; chemical change is permanent

electron configuration – the way in which electrons are arranged around the nucleus

isotopes – atoms of the same element with different masses

mass number – the total mass of the atom; the number of protons plus the number of neutrons

molecule – a group of two or more atoms that are bonded together

nucleon – proton and neutron at the centre of an atom

neutron (n^0) – the sub-atomic particle that carries no electric charge

electron (e^-) – a sub-atomic particle that carries a negative charge

Periodic Table – a chart in which elements with similar chemical and physical properties are grouped together

physical change – any process that involves a substance's change from one state (solid, liquid or gas) to another state, without changing the chemical composition of the substance; non-permanent

proton (p^+) – the sub-atomic particle that carries a positive charge

relative atomic mass – the mass of an atom of an element relative to the mass of a carbon-12 atom

Checklist for Self-evaluation

Theme 2 Topic 3

EVALUATION GUIDE: Student should be able to:

	Criteria	4	3	2	1	Comments
1	Distinguish between physical and chemical changes					
2	Distinguish between atoms and molecules					
3	Describe how the particles are arranged in the atom					
4	Define: atomic number mass number isotopes					
5	Calculate the relative atomic masses of atoms					

Code for evaluation:			
4 – Very well	3 – Well	2 – Fairly well	1 – Not well at all

Topic 4: Symbols, formulae and equations

Performance objectives

4.1 State the symbols of the first 20 elements and other common elements
4.2 Distinguish between elements, compounds and mixtures
4.3 Write chemical formulae and chemical equations
4.4 Calculate the empirical and molecular formulae of compounds
4.5 Illustrate that matter is neither created nor destroyed
4.6 State and illustrate the laws of constant composition and multiple proportions

Introduction

In this topic students will look at the first 20 elements of the Periodic Table and other common elements. Students will also learn to calculate the empirical and molecular formulae of compounds. Different chemical laws will be discussed, such as the Law of Conservation of Mass, the Law of Constant Composition and the Law of Multiple Proportions. Students will describe experiments to illustrate these chemical laws and report these experiments using the correct format for writing up an experiment. Reactions will be written as fully-balanced chemical equations.

Activity 4.1: **Elements and compounds**

INDIVIDUAL (SB p.46)

Resources

A poster or chart of the Periodic Table of elements, coloured beads to learn the difference between elements and compounds

Guidelines

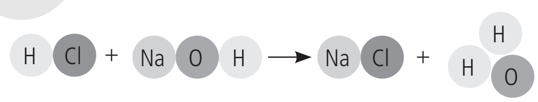
Students should be able to write the correct symbols of elements and define the difference between elements and compounds.

Refer the students to Table 4.1 on page 41 of the *Student's Book*, which shows the names and symbols of the first 20 elements in the Periodic Table, and also to Table 4.2 on p.41, which is a list of other useful elements.

Guide students to write chemical symbols and formulae correctly.

Answers

1. An element is the most basic substance from which all materials are made. A compound is a material that consists of atoms of two or more different elements that are chemically bonded together.
2. a) Carbon dioxide
   b) Water and vinegar
   c) Oxygen
   d) Sugar and vinegar. Carbon, hydrogen and oxygen
   e) Use the following symbols inside the circles: hydrogen (H), chloride (Cl), sodium (Na) and oxygen (O).



Activity 4.2: **Elements, compound and mixtures**

INDIVIDUAL (SB p.47)

Guidelines

Prepare for this activity by:

- discussing the classification of matter into elements, compounds or mixtures, using the examples provided on pages 45 to 46
- discussing Table 4.5 Examples of elements and their states on pages 43 to 44
- revising the difference between elements and compounds.

Guide the students to look for various examples of matter in their everyday life at home and at school.

Answers

1. A mixture is a combination of two or more substances in which the substances retain their own properties. A mixture's composition can vary.
2. a) C
   b) B
   c) C
3. a) An atom is the smallest unit of matter that has the properties of a chemical element.
   b) An element consists of one type of particle only and cannot be broken down into simpler substances.
   c) A compound is a substance formed when two or more elements are chemically bonded together.
4. An element consists of one kind of atom and a compound consists of two or more elements.
5. A molecule of an element consists of more than one atom of the same element and a molecule of a compound consists of more than one element.
6. a) Compound
   b) Compound
   c) Element
7.

Substance	Pure or mixture?
Oxygen and hydrogen combine to form water	Pure
Water and soil combine to form mud	Mixture
Copper and tin combine to form brass	Pure
Oxygen and carbon combine to form the gas carbon dioxide	Pure
Petrol and oil combine to make fuel for a two-stroke engine	Pure
Magnesium burns in air to form magnesium oxide	Pure
Nitrogen and oxygen are pumped into tanks to form a gas for divers to breathe under water	Mixture
During photosynthesis, plants use nutrients and carbon dioxide to make glucose	Pure
Tartaric acid and sodium bicarbonate combine to form baking powder	Mixture

Activity 4.3: Writing chemical formulae
INDIVIDUAL (SB p.50)

Guidelines

Prepare for this activity by:
- discussing the various formulae used
- defining the term 'valency'
- discussing the valencies of elements and atoms
- discussing compounds that end in '-ide'.

Guide students to write and balance chemical equations.

Answers

1. K_2SO_4
2. $CaCO_3$
3. $Al(OH)_3$
4. $Zn(NO_3)_2$
5. $CuCl_2$
6. AgBr
7. K_2O
8. NH_3
9. MgF_2
10. H_2S

Activity 4.4: Empirical and molecular formulae
INDIVIDUAL (SB p.52)

Guidelines

Prepare for this activity by:
- defining the terms empirical and molecular formulae
- encouraging students to regularly practise calculations.

Guide students to calculate the empirical and molecular formula of a compound.

Answers

1. a) CH_2O
   b) C_4H_4S
2. a) C:H:N
   b) 5:7:1
   d) $C_{10}H_{14}N_2$
3. a) 62.5% Pb; 8.45% N; 29.05% O

Element	g/ 100g	$n = \frac{m}{M}$	Simplest ratio
Pb	62.5	$\frac{62.5}{207.2} = 0.30$	$\frac{0.30}{0.30} = 1$
N	8.45	$\frac{9.45}{14.0} = 0.60$	$\frac{0.60}{0.30} = 2$
O	29.05	$\frac{29.05}{16.0} = 1.80$	$\frac{1.80}{0.30} = 6$

The empirical formula is PbN_2O_6 (or $Pb(NO_3)_2$)

b) 53.0% Al; 47.0% O

Element	g/ 100g	$n = \frac{m}{M}$	Simplest ratio
Al	53.0	$\frac{63.0}{27.0} = 1.96$	$\frac{1.96}{1.96} = 1$
O	47.0	$\frac{47.0}{16.0} = 2.93$	$\frac{2.93}{1.96} = 1.5$

To get whole numbers, we multiply by 2:
Al:O
1:1.5
thus 2:3
The empirical formula is Al_2O_3

Activity 4.5: Writing balanced chemical equations

INDIVIDUAL (SB p.55)

Guidelines

Prepare for this activity by:

- defining the terms chemical equation
- discussing the rules for writing chemical equations
- encouraging the students to regularly practise calculations.

Guide students to write and balance chemical equations.

Answers

1. $2SnO_2 + 2H_2 \rightarrow Sn + 2H_2O$
2. $3KOH + H_3PO_4 \rightarrow K_3PO_4 + 3H_2O$
3. $2KNO_3 + H_2CO_3 \rightarrow K_2CO_3 + 2HNO_3$
4. $Na_3PO_4 + 3HCl \rightarrow 3NaCl + H_3PO_4$
5. $TiCl_4 + 2H_2O \rightarrow TiO_2 + 4HCl$
6. $2C_2H_6O + 5O_2 \rightarrow 4CO_2 + 6H_2O$
7. $2Fe + \_6HC_2H_3O_2 \rightarrow 2Fe(C_2H_3O_2)_3 + 3H_2$
8. $4NH_3 + 5O_2 \rightarrow 4NO + 6H_2O$
9. $B_2Br_6 + 6HNO_3 \rightarrow 2B(NO_3)_3 + 6HBr$
10. $4NH_4OH + KAl(SO_4)_2{\cdot}12H_2O \rightarrow Al(OH)_3 + 2(NH_4)2SO_4 + KOH + 12H_2O$

Activity 4.6: The conservation of atoms

INDIVIDUAL (SB p.57)

Resources

13 coloured beads (marbles or bottle tops), reusable putty

Guidelines

Explain to the students how to use models to illustrate the conservation of atoms in the chemical reaction.

Experiment 4.1 Verify the Law of Conservation of Matter

CLASS (SB p. 57)

Resources

Chemical mass meter (scale), three 100 ml beakers, 1 $mol{\cdot}dm^3$ solution lead nitrate ($Pb(NO_3)_2$), 1 $mol{\cdot}dm^3$ solution sodium iodide (NaI)

Guidelines

This experiment is to investigate the reaction between lead nitrate and sodium iodide to verify the Law of Conservation of Matter.

Lead nitrate is toxic and must be handled with the appropriate safety precautions to prevent inhalation, ingestion and skin contact.

Experiment 4.2: Investigate the chemical reaction of an effervescent tablet and water (SB p.58)

Resources

Large test tube, water, balloon, effervescent tablet (for example, indigestion tablet), rubber band, chemical balance (mass meter), beaker

Guidelines

This experiment is to investigate the Law of Conservation of Matter (mass). The smaller you make the pieces of the effervescent tablet, the faster the reaction will take place. Any type of effervescent tablet can be used. You can place the test-tube in a test-tube holder, but then the test-tube holder should also be weighed.

Answers

1. Students should weigh the test tube and balloon on a chemical balance (mass meter) to determine the total mass.
2. A chemical reaction takes place when the effervescent tablet falls into the water. The solution starts to fizz due to the bubbles (gas) forming.
3. The total mass of the equipment before and after the reaction is the same.

Experiment 4.3: Investigate the reaction of an acid and a base (SB p.58)

Resources

Test tubes, glass beaker, 1 $mol \cdot dm^3$ sodium hydroxide solution, 1 $mol \cdot dm^3$ hydrochloric acid solution, bromothymol blue indicator

Guidelines

Be careful when mixing the hydrochloric acid and sodium hydroxide, because the mixture becomes hot very fast and if it comes into contact with your skin, it can cause a severe burn.

Answers

1. When the hydrochloric acid is added to the sodium hydroxide solution, the mixture becomes very hot very quickly.
2. Yes, the results prove the Law of Conservation of Mass.
3. $HCl + NaOH \rightarrow NaCl + H_2O$

Activity 4.7: Law of Conservation of Matter INDIVIDUAL (SB p.59)

Guidelines

To verify the Law of Conservation of Matter, the mass of the reactants should be equal to the mass of the products. Work with relative atomic masses to calculate the mass of the reactants and products.

Answers

1. a) Lead nitrate and sodium iodide
   $Pb(NO_3)_2(aq) + 2NaI(aq) \rightarrow PbI_2(s) + 2NaNO_3(aq)$
   $[(207) + (2 \times 14) + (6 \times \times 16)] + [(2 \times 23) + (2 \times 127)] \rightarrow [(207) + (2 \times 127)] + [(2 \times 23) + (2 \times 14) + (6 \times 16)]$
   $631 \rightarrow 631$
   Mass of the reactants = mass of the products
2. a) No. If the reaction takes place on a scale, the mass of the products formed will be less than the reactants, because carbon dioxide is a gas and will escape from the open beaker.
   b) $CuCO_3(s) + 2HCl(aq) \rightarrow CuCl_2(aq) + CO_2(g) + H_2O(l)$
   Number of reacting atoms:
   $1 \times Cu$
   $1 \times C$
   $3 \times O$
   $2 \times H$
   $2 \times Cl$
   Number of product atoms:
   $1 \times Cu$
   $1 \times C$
   $3 \times O$
   $2 \times H$
   $2 \times Cl$
   Number of atoms of reactants = number of atoms of products

Experiment 4.4: Determine the ratio in which elements combine (SB p.60)

Resources

9 test tubes, pipette droppers, 1 mol·dm^{-3} aqueous solutions of silver nitrate and sodium chloride, lead(II) nitrate and sodium iodide and iron(III) chloride and sodium hydroxide

Guidelines

Safety is important when conducting these experiments. Dilute solutions of chemicals are low-hazard solutions, but lead salts and their solutions are toxic.

The ratio in which elements combine will always be fixed, for example, water (H_2O) will always have a ratio of 2:1.

Experiment 4.5: Investigate the Law of Constant Composition (SB p.61)

Resources

Bunsen burner, retort stand, combustion tube, 2 test tubes, 2 watch glasses, copper powder, copper(II) carbonate, hydrogen gas

Guidelines

Safety is important when heating the test tubes. Tongs can be used to prevent your fingers from getting burnt when working with the hot test tubes.

Answers

1. The mass of the copper in both watch glasses are the same.
2. The composition of copper in copper(II) oxide will always be the same regardless of how the substance was made. In the first method only copper(II) oxide is produced when Cu burns in O_2.
   Two reactants are used to produce one product. In the second method copper (II) carbonate decomposes (breaks up) into two products, copper(II) oxide and carbon dioxide. Different methods were used to produce CuO but, in the end, the mass of the copper is still the same.

Activity 4.8: Law of Constant Composition INDIVIDUAL (SB p.62)

Answers

1. a) The Law of *Constant Composition*
   b) *Conservation of Matter*
2. a) Ca:Br
   1:2
   b) C:Cl
   1:4
   c) N:O
   1:2
   d) Al:S
   2:3

Activity 4.9: Law of Multiple Proportions INDIVIDUAL (SB p.63)

Answers

1. Nitrous oxide (N_2O) 2:1
   Nitric oxide (NO) 1:1
   Dinitrogen tetroxide (N_2O_4) 1:2
   Dinitrogen pentoxide (N_2O_5) 2:5
2. Compound A
   $\frac{1.27 \text{ g Cl}}{1.0 \text{ g Fe}} = 1.27$
   Compound B
   $\frac{1.9 \text{ g Cl}}{1.0 \text{ g Fe}} = 1.90$
   The ratio of Fe in the two compounds is 1:1
   The ratio of Cl in the two compounds: 1.27:1.90
   $\frac{1.27}{1.90}:\frac{1.90}{1.27}$
   1:1.5
   Therefore ratio is 2:3.

Revision questions: Answers

(SB p. 64)

1.

Symbol	Name
Fe	Iron
Na	Sodium
K	Potassium
Cu	Copper
B	Boron
He	Helium
Zn	Zinc
F	Fluorine
Ba	Barium
Li	Lithium
P	Phosphorus
S	Sulphur
Ar	Argon
C	Carbon
N	Nitrogen
Si	Silicon
Ag	Silver
Cl	Chlorine
Ne	Neon
H	Hydrogen
Ca	Calcium
Al	Aluminium
O	Oxygen
Be	Beryllium
Mg	Magnesium
Au	Gold
Br	Bromine

2. a) Chemical reaction
   b) Chemical equation
   c) Arrow
   d) (*s*)

3. a) $2H_2O_2 \rightarrow 2H_2O + O_2$
   b) $2SO_2 + O_2 \rightarrow 2SO_3$
   c) $4Al + 3O_2 \rightarrow 2Al2O_3$
   d) $2KClO_3 \rightarrow 2KCl + 3O_2$
   e) $2H_2S + 3O_2 \rightarrow 2H_2O + 2SO_2$
   f) $CH_4 + 2O_2 \rightarrow CO_2 + 2H_2O$
   g) $MnO_2 + 4HCl \rightarrow MnCl_2 + 2H_2O + 2Cl_2$
   h) $3Fe + 4H_2O \rightarrow Fe_3O_4 + 4H2$

4. a) The total mass of substances in a closed system remains constant, no matter what processes are acting inside the system. The mass of the products formed by a chemical reaction equals the mass of reactants that react.
   b) No. The CO_2 gas will escape during the reaction resulting in the mass of the reactants not being equal to the mass of the products.
   c) $2NaHCO_3(aq) + H_2SO_4(aq) \rightarrow Na2SO_4(aq) + 2CO_2(g) + 2H_2O(l)$
   [2(23) + 2(1) + 2(12) + 6(16)] + [2(1) + 32 + 4(16)] → [2(23) + 32 + 4(16)] + [2(12) + 4(16)] + [4(1) + 2(16)]
   168 + 98 → 142 + 88 + 36
   266 → 266

5. a) Incorrect. The Law of Conservation of Mass operates 100% of the time.
   b) Correct
   c) Incorrect. The Law of Conservation of Mass will still operate even when more reactants are involved in the reaction.
   d) Incorrect. The Law of Conservation of Mass is valid, because the missing 12.3 g is the mass of the carbon dioxide that escaped.
   e) Incorrect. The Law of Conservation of Mass applies to solids and liquids and gases in a closed container.

6. a) 1:2
   b) 1:2
   c) 2:3
   d) 2:1
   e) 1:4
   f) 1:2

7.

	Compound name	Number of atoms (in one molecule)	Atomic symbol	Compound formula
a)	carbon dioxide	1 carbon 2 oxygen	C O	CO_2
b)	water	2 hydrogen 1 oxygen	H O	H_2O
c)	sulphur trioxide	1 sulphur 3 oxygen	S O	SO_3
d)	oxygen	2 oxygen	O	O_2
e)	nitrogen dioxide	1 nitrogen 2 oxygen	N O	NO_2
f)	carbon monoxide	1 carbon 1 oxygen	C O	CO
g)	hydrogen fluoride	1 hydrogen 1 fluorine	H F	HF
h)	methane (carbon tetrahydride)	1 carbon 4 hydrogen	C H	CH_4

How are you doing?

Take this opportunity to ask learners if there is anything that they do not understand. You can check their understanding by asking them some questions about the information covered in the unit. Explain anything that learners do not understand.

Key words

chemical bond – the force that holds atoms together in a compound

chemical equation – a symbolic representation of a chemical reaction in terms of chemical formulae or symbols

chemical reaction – a process that leads to a chemical substance changing into a different substance

compound – a material that consists of atoms of two or more different elements that are chemically bonded together

conserved – remains the same

element – a substance that cannot be broken down into simpler substances by chemical methods

empirical formula – is the simplest whole-number ratio of the elements making up the compound

Law of Conservation of Matter – in a chemical reaction, the sum of the mass of the reactants equals the sum of the mass of the products

Law of Constant Composition – the composition of a substance is always the same, regardless of how the substance was made or where the substance is found

Law of Multiple Proportions – when two elements combine with each other to form more than one compound, the mass of one element that combines with the fixed mass of the other are in a ratio of small whole numbers

mixture – a combination of two or more substances in which each substance still has its own properties

molecular formula – a formula for a molecule based on the actual number of atoms of each type in the compound; the same as, or a multiple of, the empirical formula

pure substance – consists of one type of particle only

radical – a stable group of atoms that take part in a chemical reaction as a unit

valency – the combining power of an atom of an element when it bonds to form a compound

Checklist for Self-evaluation

Theme 2 Topic 4

EVALUATION GUIDE: Student should be able to:

	Criteria	4	3	2	1	Comments
1	State the symbols of the first 20 elements and other common elements					
2	Distinguish between elements, compounds and mixtures					
3	Write chemical formulae and chemical equations					
4	Calculate the empirical and molecular formulae of compounds					
5	Illustrate that matter is neither created nor destroyed					
6	State and illustrate the laws of constant composition and multiple proportions					

Code for evaluation:			
4 – Very well	3 – Well	2 – Fairly well	1 – Not well at all

Topic 5: Chemical combination

Performance objectives

5.1 Identify the first 20 elements of the Periodic Table
5.2 Write the electronic configuration of the atoms of the first 20 elements
5.3 Explain the concept of atomic numbers
5.4 Arrange the elements in the Periodic Table based on their atomic numbers
5.5 Differentiate between various types of chemical bonding
5.6 Name compounds by their conventional and IUPAC names
5.7 Distinguish between solid, liquid and gaseous states of matter
5.8 Discuss the kinetic theory and its applications

Introduction

In this topic students will look at the first 20 elements in the Periodic Table and how to draw the electron configuration of these elements. You will discuss the different types of bonds between atoms (strong bonds) and the types of bonds between molecules (weak bonds).You will name compounds using the two systems of naming: the conventional system and the IUPAC system. The three states of matter (solid, liquid and gas) will also be discussed and how the kinetic theory applies to these states.

Activity 5.1 The Periodic Table

INDIVIDUAL (SB p.67)

Resource

Blank Periodic Table template

Guidelines

Guide the students to identify the first 20 elements of the Periodic Table.

Guide a class discussion on the function and form of the Periodic Table. Also discuss how the Periodic Table is divided into columns and rows, and the names of the columns and rows.

Students should be able to complete a simple table listing elements and their group numbers.

Answers

1.

Element	Group number
Sodium	1
Magnesium	2
Chlorine	17
Neon	18

2. a) Group
   b) Period
   c) Atomic number
   d) Transition metals

3.

Column A	Column B
Sodium	Na
Silicon	Si
Calcium	Ca
Carbon	C
Chlorine	Cl
Potassium	K
Phosphorus	P

Activity 5.2 Electron configuration

INDIVIDUAL (SB p.68)

Resource

Blank Periodic Table template

Guidelines

Draw the electronic configuration of the first 20 elements of the Period Table on the blank template.

Guide the students in a class discussion on the electronic configuration of elements.

Students should be able to complete a simple table showing the electronic configuration of elements.

Answers

1. Oxygen electron configuration: 2, 6
   Aluminium electron configuration: 2, 8, 3
   Sulphur electron configuration: 2, 8, 6

2.

Element	Symbol	Atomic number	Electrons	Electron configuration	Group number	Period number
Sodium	Na	11	11	2, 8, 1	1	3
Calcium	C	20	20	2, 8, 8, 2	2	4
Nitrogen	N	7	7	2, 5	5	2
Neon	Ne	10	10	2, 8	8	2
Boron	B	5	5	2, 3	3	2
Magnesium	Mg	12	12	2, 8, 2	2	3

Activity 5.3 Investigating ionic compounds

INDIVIDUAL (SB p.72)

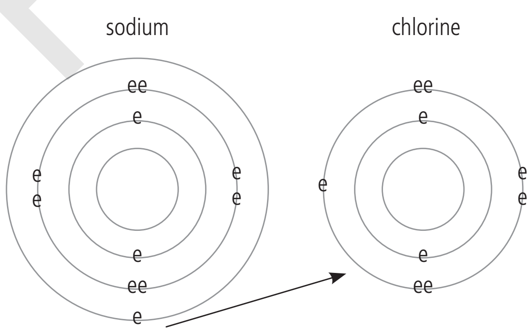
Guidelines

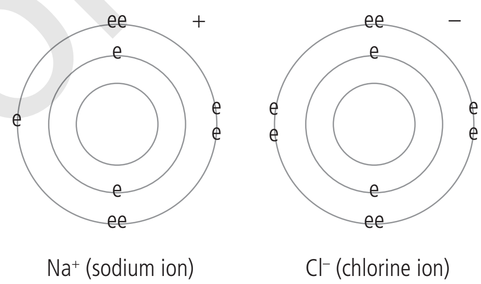
In this activity students must be able to use the Lewis dot diagrams and electron shell diagrams to investigate ionic compounds. Explain what makes an ionic compound a strong bond.

Guide the students by drawing a Lewis dot diagram and use it in a class discussion to show how it is one model that is used to explain the bonding of atoms. Encourage the students to participate.

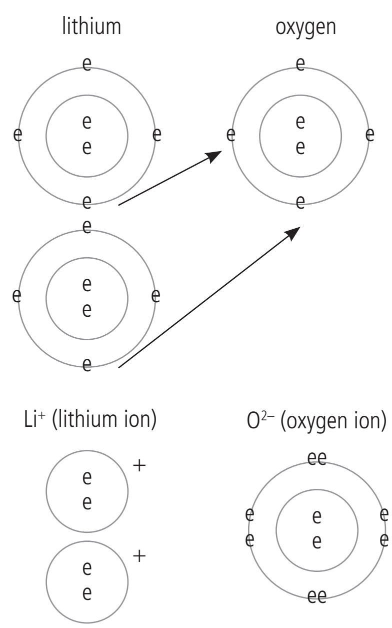
Answers

1. a) Sodium reacts with chlorine

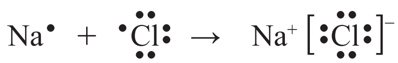




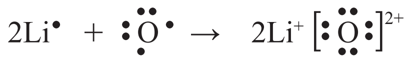
b) Lithium reacts with oxygen.



2. a) Sodium reacts with chlorine



b) Lithium reacts with oxygen.



3. a) Lithium bromide, LiBr
   b) Calcium chloride, $CaCl_2$
   c) Sodium oxide, Na_2O

Activity 5.4 Covalent bonds

INDIVIDUAL (SB p.74)

Resources

Some liquids, such as oil, water

Guidelines

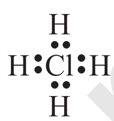
Guide the students to be able to differentiate between various types of chemical bonding. Explain covalent bonds and their characteristics and what makes them strong bonds.

Use simple demonstrations to illustrate the type of bonds in liquids.

Answers

1. a) Hydrogen chloride

b) Methane (CH_4)



c) Hydrogen fluoride

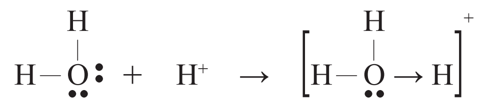
2. a) H_2O_2 and C_2H_4
   b) Eight electrons
   c) There is a double bond between the two carbon atoms in ethene.

Activity 5.5 Coordinate covalent bonds

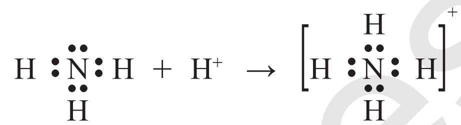
INDIVIDUAL (SB p.74)

Answers

1. In a coordinate bond one atom donates both electrons.
2. a)



b)



Activity 5.6 Investigate metal bonding in aluminium

INDIVIDUAL (SB p.75)

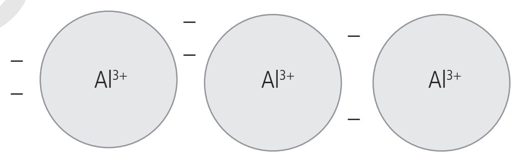
Guidelines

Explain metal bonding and its characteristics and what makes it a strong bond.

Use aluminium and the electron-sea model to explain why metals are good electrical and heat conductors.

Answers

The positive aluminium atomic kernel has 13 protons, 14 neutrons and 10 electrons.



Activity 5.7 Ionic substances

INDIVIDUAL (SB p.78)

Resources

Table salt, chlorine, Bunsen burner

Guidelines

Explain ionic substances and their characteristics and what makes them a strong bond.

Use a simple demonstration with the salt and the chlorine to illustrate the properties of ionic substances.

Answers

1. Group 1, alkali metals
2. 11
3. 17
4. a) Sodium loses 1 electron
   b) No change
5. Cl^-
6. The valency of sodium is 1 and the valency of chlorine is 1.
7. The ions in the ionic crystal lattice are held together by strong forces. A large amount of energy is needed to break these forces to release the ions.

Activity 5.8 Types of intermolecular forces (weak bonds) INDIVIDUAL (SB p.81)

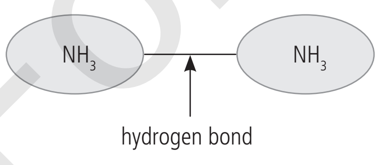
Guidelines

Guide the students to be able to differentiate between various types of forces. Explain Van der Waals' forces and hydrogen bonds, their characteristics, and what makes them a weak bond.

Students should be able to categorise substances based on type of bonding.

Answers

1. a) Van der Waal's force
   b) Van der Waal's force
   c) Hydrogen bonding
   d) Van der Waal's force
   e) Van der Waal's force
2.



3. Dispersion forces, dipole-dipole forces, hydrogen bonds
4. a) Covalent bond
   b) London dispersion forces

Activity 5.9 Conventional and IUPAC naming systems INDIVIDUAL (SB p.83)

Resources

The various tables in the *Student's Book* that depict conventional and IUPAC names of some common substances

Guidelines

Explain what the IUPAC system is, as well as the rules for naming compounds.

Guide the students to be able to name common substances by their conventional and IUPAC names. A class test will assist the students to practise giving the conventional and IUPAC names.

Answers

1. a) Sodium carbonate
   b) Potassium nitrate
   c) Ammonium chloride
   d) Magnesium oxide
2. a) Iron(III) oxide
   b) Calcium trioxocarbonate
   c) Tetraoxo sulphate(VI) acid
   d) Copper(II) chloride dihydrate
3. a) $(NH_4)2SO_4$
   b) Na_3PO_4
   c) $FeSO_4 \cdot 5H_2O$
   d) NaI
   e) CO_2
   f) HCl

Activity 5.10 States of matter INDIVIDUAL (SB p.87)

Resources

Pictures from magazines or the Internet; some physical examples, such as candles, bottle of water or an aerosol can

Guidelines

Matter is anything that has mass and occupies space. Matter and materials are classified according to their properties. One of these properties is the phase, or state, of the matter.

Guide the students to be able to distinguish between the different states of matter, such as solid, liquid and gas. Encourage them to think of common substances at their homes that are either solids, liquids or gases.

Explain what the differences are between the states of matter. Encourage a class discussion on the states of matter and encourage the students to participate.

Explain how a change of state in matter can take place.

Answers

1. a) Melting: Change of state from solid to liquid
   b) Freezing: Change of state from liquid to solid
   c) Condensation: Change of state from gas to liquid
2. a) A = solid, B = gas and C = liquid
   b) a. Deposition
      b. Sublimation
      c. Melting or fusion
      d. Freezing
      e. Evaporation or vaporisation
      f. Condensation or liquefaction
3. A = solid
   - Solids are hard and keep their shape.
   - Many solids have a crystalline form that makes them hard and brittle.
   - Other solids are soft and pliable (flexible).
   - Solids cannot be compressed.

   B = gas
   - Gases move fast and quickly fill the available space. (They diffuse well.)
   - Gases are compressible.

   C = liquid
   - Liquids can flow easily.
   - They always take the shape of the container that they are in, but no matter what their shape, liquids always keep the same volume.
   - Liquids are usually not compressible.
4. a) Gas state
   b) Evaporation
   c) Energy is removed

Activity 5.11 Kinetic theory and its applications

INDIVIDUAL (SB p.88)

Resources

camphor balls; some liquids; pictures of snowflakes

Guidelines

Explain the various changes which can affect the state of substances due to kinetic theory.

Answers

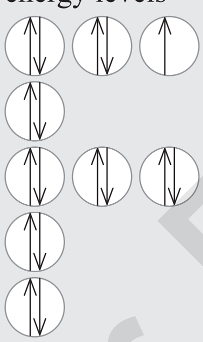
1. a) Evaporation can happen at any temperature and boiling happens at a specific temperature.
   b) Sublimation happens when a solid changes to a gas and evaporation happens when a liquid changes to a gas.
2. You can walk in an open space even if the air is moving (wind), because the particles are far apart and can be compressed, but you cannot walk through a brick wall, because the particles are packed very closely and are almost incompressible.
3. In container A the processes are in equilibrium, as evaporation and condensation are taking place at the same time. Because it is a closed cantainer, the level of the water remains constant. In container B evaporation is taking place and the level of the water drops, because the water is leaving the container.

Revision questions: Answers

(SB p. 89)

1.

	1	2	13	14	15	16	17	18
1	1 H							2 He
2	3 Li	4 Be	5 B	6 C	7 N	8 O	9 F	10 Ne
3	11 Na	12 Mg	13 Al	14 Si	15 P	16 S	17 Cl	18 Ar
4	19 K	20 Ca						

2. a) 19
   b) J
   c) D
   d) 9
   e) A
   f) A, B, C, D
   g) F
   h) 8
   i) K and L are noble gases with full outer energy levels
3. a) 

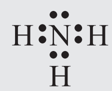
   b) $1s^22s^22p^63s^23p^5$
   c) 17 protons, 18 neutrons and 17 electrons
   d) Chlorine
4. Covalently bonded substances: Simple molecules generally have low melting and boiling points. The molecules are held together by weak forces. The strength of these forces determines the melting and boiling points of the individual substances. Ionic substances: Ionic compounds are solids with high melting and boiling points. The ions in the ionic crystal lattice are held together by strong forces. A large amount of energy is needed to break these forces to release the ions.
5. a) Cl_2

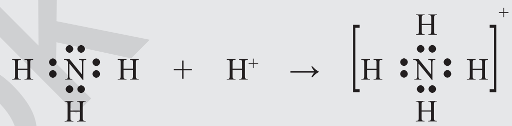
   b) CS_2

6. a)

   b) NH_3 has a lone pair that it can share with the H^+ ion, which has an empty shell.
   c)

7. a) Van der Waals' forces
   b) Van der Waals' forces
   c) Hydrogen bonds
   d) Van der Waals' forces
   e) Van der Waals' forces
8. a) Magnesium carbonate
   b) Sodium chloride
   c) Ammonium bromide
   d) Magnesium sulphate
9. a) Potassium oxide
   b) Sodium hydrogen trioxocarbonate(IV)
   c) Tetraoxophosphate(V) acid
10. a) $CaCO_3$
    b) Na_3PO_4
    c) K_2O
    d) H_2O
11. a) Gaseous
    - Gases move fast and quickly fill the available space. (They diffuse well.)
    - Gases are compressible.

b) Liquid
   - Liquids can flow easily.
   - They always take the shape of the container that they are in, but, no matter what their shape, liquids always keep the same volume.
   - Liquids are usually not compressible.

c) Solid
   - Solids are hard and keep their shape.
   - Many solids have a crystalline form that makes them hard and brittle.
   - Other solids are soft and pliable (flexible).
   - Solids cannot be compressed.

12. The principles of the particle model are:
    - All matter consists of small particles.
    - There are spaces between particles.
    - The particles are in constant motion.
    - There are attractive and repulsive forces between particles.
13. When energy is supplied by heating a solid, the solid particles vibrate more vigorously. Eventually, the particles have enough energy to break away from the solid arrangement and the solid melts to form a liquid.

How are you doing?

Take this opportunity to ask learners if there is anything that they do not understand. You can check their understanding by asking them some questions about the information covered in the unit. Explain anything that learners do not understand.

Key words

anions – non-metals that have gained electrons and formed negatively-charged ions

bonding – when atoms combine with one another to form compound

cations – metals that have lost their outer electrons and formed positively-charged ions

coordinate covalent bond – a bond in which one atom donates both electrons

covalent bond – the most common chemical bond; two atoms share an electron pair

crystal lattice – the arrangement of ions in a fixed pattern

dative covalent bond – a bond in which the shared pair of electrons both come from the same atom

deposition – when a gas changes state directly into a solid

diatomic molecule – a molecule with two atoms

dipole – molecule with two poles, a slightly negative and a positive side

electrode – an electrical conductor through which an electric current flows

electron configuration – the way in which electrons are arranged around the nucleus of an atom

evaporation – process occurring at the surface of a liquid when a liquid becomes a gas at temperature below its melting point

groups – the vertical columns of elements in the Periodic Table

hydrogen bond – a type of dipole–dipole force; a force between a hydrogen atom on one molecule and a small atom (N, O or F) of another molecule

induced dipole–induced dipole forces (also known as dispersion forces, momentary dipole forces or London forces) – momentary dipoles that are formed when two non-polar molecules approach each other to produce a small attraction between the molecules

intermolecular forces – forces between molecules

kinetic theory of matter – describes the movement of the particles in the three states

Lewis dot diagram – shows only the valence electrons of an element

non-polar molecule – molecule with no net dipole

periods – the horizontal rows in the Periodic Table

polar molecules (see dipoles) – molecules with a slightly negative and positive side

prefix – words or parts of words that go in front of the element name

salt – an ionic compound formed by the replacement of one or more hydrogen ions of an acid by a metallic ion or ammonium ion

states of matter – solid, liquid or gas

sublimation – when a solid changes state directly into the gaseous state

the particle model of matter – matter in all three states is made up of particles

valence electrons – the number of electrons in the outermost shell of an atom

Checklist for Self-evaluation

Theme 2 Topic 5

EVALUATION GUIDE: Student should be able to:

	Criteria	4	3	2	1	Comments
1	Name the first 20 elements on the periodic table					
2	Write the electronic configuration of the atoms of the first 20 elements					
3	Explain the concept of atomic numbers					
4	Arrange the elements in the Periodic Table based on their atomic numbers					
5	Differentiate between various types of chemical bonding					
6	Name compounds by their conventional and IUPAC names					
7	Distinguish between solid, liquid and gaseous states of matter					
8	Discuss the kinetic theory and its applications					

Code for evaluation:			
4 – Very well	3 – Well	2 – Fairly well	1 – Not well at all

Topic 6: Gas laws
Performance objectives
6.1 Demonstrate diffusion of gases **6.2** State the relationship between rate of diffusion and density of gas/vapour **6.3** Show how heat affects the volume of a given mass of gas **6.4** Explain the Kelvin scale of temperature and its relationship to the Celsius scale **6.5** Explain the effect of pressure on the volume of a gas **6.6** Explain the effect of temperature and pressure on the volume of gas **6.7** Show that $PV = nRT$ is the general gas equation

Introduction

In this topic we will look at the different gas laws. Although there are wide differences in chemical properties of different gases, all the gases more or less obey the gas laws. The gas laws deal with how gases behave with respect to pressure, volume, temperature and amount. We will define the gas laws, describe some of the experiments relating to these laws and perform the necessary calculations. Molar volume of gases, Avogadro's number and the mole concept are terms that will also be discussed.

Experiment 6.1: Verify Boyle's Law

(SB p.95)

Resources

Pressure gauge, 10 ml syringe, 3 cm silicone tubing to attach syringe to pressure gauge

Answers

1. How does the pressure change when the volume is changed?
2. Constant variable: temperature; amount (mass) of gas
   Dependent variable: pressure
   Independent variable: volume
3. The pressure of a fixed amount of gas at constant temperature increases as the volume is decreased; the pressure of a fixed amount of gas is inversely proportional to volume at constant temperature.
   $V \propto \frac{1}{P}$
4. The particles in a gas have kinetic energy and move around at high speeds. They collide with the sides of the container to exert a pressure. The magnitude of the pressure is determined by the number of collisions on an area and the intensity of the collisions. If the temperature in the experiment remains constant, the average kinetic energy of the gas particles also remains constant. The intensity of the collisions does not change. The pressure is therefore determined only by the number of collisions on a specific area. When the volume is decreased, the area for collisions also decreases. The number of gas particles is the same, so a larger number of collisions per area will occur. The pressure will thus increase.

Experiment 6.2: Verify Charles' Law

(SB p.98)

Resources

Glass beaker, 10 ml syringe, stopper for syringe, water bowl, ice, Bunsen burner, tongs

Guidelines

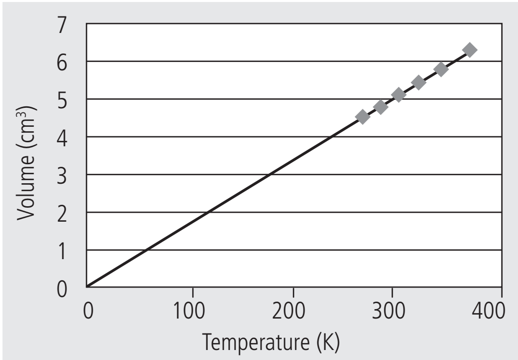
Conduct the experiment using the method in the *Student's Book*. A set of experimental results is recorded in the table.

Temperature (°C)	Temperature (K)	Volume (cm^3)	$\frac{V}{T}$ (cm^3/K)
0	273	4.5	0.01648
20	293	4.8	0.01638
40	313	5.0	0.01597

60	333	5.5	0.01652
80	353	5.8	0.01643
100	373	6.2	0.01662

Answers

1.



2. The volume of a fixed amount of gas maintained at atmospheric pressure is directly proportional to the temperature of the gas.

   $V \propto T$ or $V = kT$

3. When the temperature of a gas is increased, the average kinetic energy of the gas particles also increases. The speed of the particles increases and they can cover larger distances than they could at a lower temperature.

Activity 6.1: Investigate pressure–temperature relationships in a gas

(SB p.99)

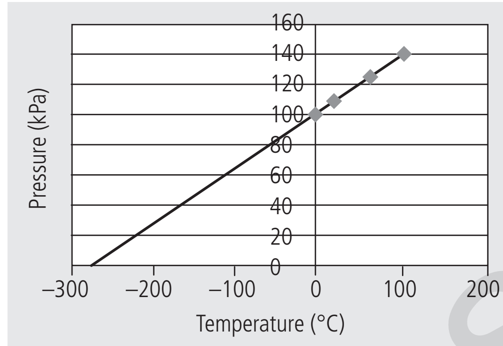
Guidelines

Guide a class discussion on the experiment which was done.

Students should be able to write an hypothesis, with a conclusion, to the experiment done.

Answers

1. When the temperature of a fixed volume of gas is increased, the pressure of the gas increases.
2. Dependent variable: pressure
   Independent variable: temperature
   Fixed variables: volume; mass/number of moles of gas
3. Graph of pressure against temperature



4. At −273 °C the pressure is zero.
5. The pressure of a fixed mass of gas is directly proportional to the temperature in Kelvin. $P \propto T$. Yes, the hypothesis was correct.
6. $t = (T - 273) = 173 - 273 = -100$ °C
   On the graph −100 °C corresponds to a pressure of 64 kPa.

Experiment 6.3: Verify Gay-Lussac's Law

(SB p.100)

Resources

Round-bottomed flask fitted with a Bourdon gauge, litre beaker filled with crushed and melting ice, tripod and gauze, Bunsen burner, thermometer

Guidelines

In this experiment, a fixed volume of gas is subjected to temperature changes and the resultant pressure change is measured with a Bourdon pressure gauge. A calibrated reference graph is used to read off the corresponding temperature. This set-up is also known as a constant volume thermometer. It uses the pressure–temperature relationship to measure temperature.

Guide a class discussion on the principles of Gay-Lussac's Law.

Students should be able to state Gay-Lussac's Law and formulate an hypothesis for the experiment, with a conclusion.

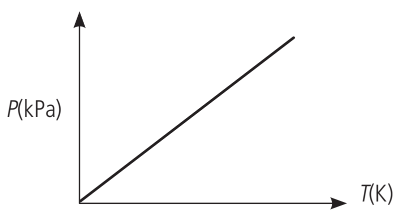
Answers

1. When the temperature of a fixed volume of gas is increased, the pressure rises.

2. Students' own pressure and temperature readings should be recorded in a table such as the one below.

	Ice	Tap water	Boiling water
Pressure in kPa			
Temperature in °C			100
Temperature in K			

3. A graph of P (in kPa) against T (in K)



4. The pressure of a fixed amount of gas is directly proportional to the absolute temperature. $P \propto T$

Experiment 6.4 Observe the Brownian motion of particles (SB p.102)

Resources

Smoke cell with a light source and lens, light microscope, 12 V DC power source, microscope cover-slip, smoke source (for example paper and matches)

Guidelines

Guide a class discussion on this experiment.

Students should be able to observe and confirm Brownian motion.

Experiment 6.5 Diffusion of gases (SB p.103)

Resources

Concentrated ammonia solution, concentrated hydrochloric acid, cotton wool, glass tube, rubber stoppers, tape, stop watch, metre rule

Guidelines

Guide a class discussion on the results of the experiment.

Students should be able to compare the rates of diffusion of two gases: ammonia and hydrogen chloride.

Activity 6.2: Graham's Law

INDIVIDUAL (SB p.104)

Answers

1. N_2 and HCl
   $M(N_2) = 2 \times 14 = 28\ g{\cdot}mol^{-1}$
   $M(HCl) = 1 + 35.5 = 36.5\ g{\cdot}mol^{-1}$
   $$\frac{rate_{HCl}}{rate_{N_2}} = \sqrt{\frac{M_{N_2}}{M_{HCl}}} = 0.88$$
   This means that nitrogen diffuses 0.88 times faster than hydrogen chloride.
2. NO_2 and C_3H_8
   $M(NO_2) = 14 + (2 \times 16) = 46\ g{\cdot}mol^{-1}$
   $M(C_3H_8) = (3 \times 12) + (8\ \ 1) = 44\ g{\cdot}mol^{-1}$
   $$\frac{rate_{NO_2}}{rate_{C_3H_8}} = \sqrt{\frac{M_{C_3H}}{M_{NO_2}}} = 0.98$$
   This means that C_3H_8 (propane) diffuses 0.98 times faster than NO_2 (nitrogen dioxide).

Activity 6.3 Avogadro's number and the mole concept (SB p. 105)

Answers

1. Number of atoms $= n \times N_A = 0.45 \times 6.02 \times 10^{23} = 2.709 \times 10^{23}$
2. Number of atoms $= n \times N_A = 0.2 \times 6.02 \times 10^{23} = 1.204 \times 10^{23}$
3. Number of atoms $= n \times N_A = 1.058 \times 6.02 \times 10^{23} = 6.369 \times 10^{23}$
4. Number of atoms $= n \times N_A = 0.75 \times 6.02 \times 10^{23} = 4.515 \times 10^{23}$

Activity 6.4: Molar volume of gases

INDIVIDUAL (SB p.106)

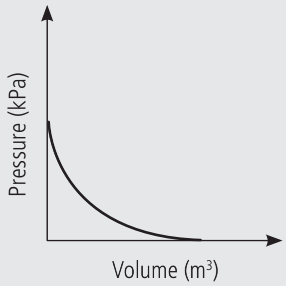
Answers

1. a) $V = n \times V_m = 1.5 \times 22.4 = 33.6\ dm^3$
   b) $V = n \times V_m = 0.1 \times 22.4 = 0.224\ dm^3$
   c) $V = n \times V_m = 3 \times 22.4 = 67.2\ dm^3$
2. a) $n = \frac{V}{V_m} = \frac{112}{22.4} = 5\ mol$
   b) $n = \frac{V}{V_m} = \frac{22.5}{22.4} = 1.004\ mol$

Revision questions: Answers

(SB p. 109)

1. a) A
   b) D
   c) B
2. a)



   b) For all values of P and V, PV is constant ($PV = 1.2$ J).

   c) $P \propto \frac{1}{V}$

   d) Boyle's Law
3. $V_2 = 4.19\text{ cm}^3$

$$\frac{V_1}{T_1} = \frac{V_2}{T_3}$$

$$\frac{4.73\text{ cm}^3}{308\text{ K}} = \frac{V_2}{273\text{ K}}$$

$V_2 = 4.19\text{ cm}^3$

4. $V_2 = 718.10\text{ cm}^3$

$$\frac{P_1V_1}{T_1} = \frac{P_2V_2}{T_2}$$

$$\frac{196\text{ kPa} \times 250\text{ cm}^3}{290\text{ K}} = \frac{80\text{ kPa} \times V_2}{340\text{ K}}$$

$V_2 = 718.10\text{ cm}^3$

5. $P_2 = 173$ kPa

$$\frac{P_1V_1}{T_1} = \frac{P_2V_2}{T_2}$$

$$\frac{108\text{ kPa} \times 210\text{ cm}^3}{294\text{ K}} = \frac{P_2 \times 410\text{ cm}^3}{340\text{ K}}$$

$P_2 = 173$ kPa

6. a) $\frac{P_1}{T_1} = \frac{P_2}{T_2}$

$$\frac{120}{291} = \frac{148}{T_2}$$

$T_2 = 358.9$ K
Temperature in °C = 358.9 – 273 = 85.9 °C

   b) No. If the ball is made of a material that can stretch, the ball will increase in volume if the temperature and pressure increase.
   c) $PV = nRT$

$$n = \frac{PV}{RT}$$

$$= \frac{(1.2 \times 10^5\text{ Pa})(4 \times 10^{-4}\text{ m}^3)}{(8.31\text{ J·K}^{-1}\text{·mol}^{-1})(300\text{ K})}$$

$= 0.02$ mol

7. $\frac{P_1V_1}{T_1} = \frac{P_2V_2}{T_2}$

$$\frac{101.3\text{ kPa} \times V_1}{273\text{ K}} = \frac{260\text{ kPa} \times 200\text{ dm}^3}{260\text{ K}}$$

$V_1 = 539\text{ dm}^3$

8. a) CO_2 and Br_2
   $M(CO_2) = 12^+(2 \times 16) = 44\text{ g·mol}^{-1}$
   $M(Br_2) = 2 \times 80 = 160\text{ g·mol}^{-1}$

$$\frac{\text{rate}_{Br_2}}{\text{rate}_{CO_2}} = \sqrt{\frac{M_{CO_2}}{M_{Br_2}}} = \sqrt{\frac{44}{160}}$$

$= 0.52$
This means that CO_2 will diffuse 0.52 times faster than Br_2.

   b) SO_3 and Cl_2
   $M(SO_3) = 32^+(3 \times 16) = 80\text{ g·mol}^{-1}$
   $M(Cl_2) = 2 \times 35.5 = 71\text{ g·mol}^{-1}$

$$\frac{\text{rate}_{Cl_2}}{\text{rate}_{SO_3}} = \sqrt{\frac{M_{SO_3}}{M_{Cl_2}}} = \sqrt{\frac{80}{71}}$$

$= 1.06$
This means that Cl_2 will diffuse 1.06 times faster than SO_3.

9. a) Number of CO_2 molecules = 0.057 mol × 6.02×10^{23} = 3.43×10^{22} molecules
   b) Number of atoms in N_2 = 3 mol × 6.02×10^{23} = 1.81×10^{24} atoms
   c) Number of O_2 molecules = 1.5 mol × 6.02×10^{23} = 9.03×10^{23} molecules
10. a) Both the amount of gas and the temperature of the gas had to remain constant. A change in temperature would affect both the pressure and volume readings. We assume that the amount of gas remained constant,

from the statement that the gas was enclosed.

$\frac{1}{V} = 5.0\ dm^{-3}$

Therefore, $V = \frac{1}{5.0\ dm^{-3}}$

$P_1V_1 = P_2V_2$

Therefore, $V_2 = \frac{P_1V_1}{P_2}$

$= \frac{100\ kPa \times 0.20\ dm^3}{150\ kPa}$

$= 0.13\ dm^3$

$X = \frac{1}{V}$

$= \frac{1}{0.13\ dm^3}$

$= 7.5\ dm^{-3}$

c) Trial B was conducted at a lower temperature. The product of pressure and volume is an indication of the energy content of the system and is measured in joules. The temperature of a gas is an indication of the average kinetic energy of its particles. The PV values for trial B are smaller than for trial A, thus indicating that the temperature for that trial was lower.

How are you doing?

Take this opportunity to ask learners if there is anything that they do not understand. You can check their understanding by asking them some questions about the information covered in the unit. Explain anything that learners do not understand.

Key words

Avogadro's Law – at constant pressure and temperature, the volume of a gas is directly proportional to the amount of gas molecules of the gas present

Avogadro's number (N_A) – the number of elementary particles (molecules, atoms or compounds) per mole of a substance; $N_A = 6.02 \times 10^{23}$

Boyle's Law – the volume of a fixed (constant) amount of gas is inversely proportional to the pressure on the gas if the temperature remains constant

Brownian motion – the random movement of microscopic (extremely small) particles suspended in a gas or liquid

Charles' Law – the volume of a fixed amount of gas at constant pressure is directly proportional to the Kelvin temperature of the gas

density – the relationship between the mass of a substance and how much space (volume) it takes up

diffusion – the process by which molecules move from an area of high concentration to an area of low concentration

gas – the state in which particles are arranged randomly, with large empty spaces between them

gas laws – the specific relationships between variables such as pressure (P), temperature (T), volume (V) and the amount of substance (n)

Gay-Lussac's Law – the pressure of a fixed amount of gas is directly proportional to the absolute (Kelvin) temperature

Graham's Law – at constant temperature and pressure, the rate of diffusion of two gases is inversely proportional to the square roots of their molar masses or density

ideal gas equation – $PV = nRT$ (where $R = 8.31\ J{\cdot}K^{-1}{\cdot}mol^{-1}$)

Kelvin temperature scale – has absolute zero (–273 °C) as the starting point; one kelvin (K) is equal in magnitude to 1 °C

kinetic energy – energy available as a result of the motion of an object

molar volume of a gas – at standard temperature and pressure (STP), one mole of gas occupies a volume of 22.414 dm^3 or 22.414 litres

moles – the number of atoms or molecules

rate – change per second

universal gas constant – $R = 8.31\ J{\cdot}K^{-1}{\cdot}mol^{-1}$

Checklist for Self-evaluation

Theme 2 Topic 6

EVALUATION GUIDE: Student should be able to:

	Criteria	4	3	2	1	Comments
1	Demonstrate diffusion of gases					
2	State the relationship between rate of diffusion and density of gas/ vapour					
3	Show how heat affects the volume of a given mass of gas					
4	Explain the Kelvin scale of temperature and its relationship to the Celsius scale					
5	Explain the effect of pressure on the volume of a gas					
6	Show that $PV = nRT$ is the general gas equation					

Code for evaluation:			
4 – Very well	3 – Well	2 – Fairly well	1 – Not well at all

THEME 3

Chemistry and the environment

Topic 7: Standard separation techniques for mixtures
Performance objectives
7.1 State the different standard methods of separating mixtures and their individual applications **7.2** Manipulate different apparatus for separation techniques **7.3** Draw separation technique apparatus **7.4** State the criteria for purity **7.5** Distinguish between pure and impure substances

Introduction

Chemistry is the study of the composition, structure, properties and reactions of matter. Matter is anything that has mass and occupies space. When we talk about matter, we usually talk about a substance. There are literally millions of different kinds of substances. Chemists have developed categories in which to organise substances. If we examine a substance and decide which category it belongs in, we are classifying it.

Experiment 7.1: Determine the melting point of ice and the boiling point of water (SB p. 113)

Resources

Glass beaker, crushed ice, thermometer, wire gauze, tripod, Bunsen burner

Answers

1. At about 0 °C and at about 100 °C
2. The temperature remains constant when there is a change of state.
3. In the ice, the water molecules are packed in a crystal lattice. The molecules vibrate about their fixed positions. In the liquid water, the water molecules have more energy and can glide over each other. In the water vapour, the water molecules have even more energy and can move about freely.

Activity 7.1: Classification of matter

INDIVIDUAL (SB p.114)

Resources

drawings of atoms representing elements, examples of common everyday substances, such as water, sand, common salt

Guidelines

Guide the students to recognise common everyday substances as matter.

Guide a class discussion on the different types of matter.

Answers

1. a) A, B
   b) A
   c) B
   d) C, D, E
   e) D
   f) C
2. a) Element
   b) Element
   c) Mixture
   d) Compound
   e) Compound

Experiment 7.2: Investigate a solution
(SB p.117)

Resources

Table salt, beaker, tap water, spoon, Bunsen burner, wire gauze, tripod

Answers

1. The solute is the salt and the solvent is water.
2. Salt
3. It should taste and smell salty and feel hard.
4. a) A solution is formed when a solute dissolves in a solvent to form a homogenous mixture. The solute spreads evenly throughout the solvent and it is no longer possible to distinguish between the solute and the solvent.
   b) A solute can be recovered from the solvent by means of different separation techniques, for example evaporation, crystallisation, etc.

Activity 7.2: Mixtures INDIVIDUAL (SB p.117)

Guidelines

Students should be able to investigate the relationship between temperature and volume of a fixed amount of gas.

Answers

1.

Mixture	Homogeneous or heterogeneous	Phases
Mineral water	a) Homogeneous	Minerals (solid), water (liquid)
Gasoline	b) Homogeneous	Different hydro carbons (liquids)
Smoke	c) Homogeneous	Smoke d), air (gas)
Air	e) Homogeneous	(gasses)
Copper sulphate dissolved in water	f) Homogeneous	g) Solid copper sulphate, liquid water
Fizzy drink	h) Homogeneous	Water (liquid), air (gas)

2. Air consists of a mixture of different gases and can thus be classified as impure. Mixtures are physical combinations of two or more different substances that are not chemically combined. The gases are not in a fixed ratio and they maintain their chemical and physical identities. The gases can also be separated by mechanical means, for example, by means of fractional distillation.

Experiment 7.3: Decanting (SB p.121)

Resources

2 test tubes, test-tube rack, lead nitrate solution (0.1 M), sodium carbonate solution (0.1 M)

Guidelines

Demonstrate various decanting methods.

Answers

1. Precipitate
2. Suspension
3. Suspensions will settle when left standing undisturbed.
4. Filtration

Experiment 7.4: Making a solar still
(SB p.125)

Resources

Salt water, a large plastic bowl, a cup, plastic sheeting and a heavy object, such as a stone

Guidelines

Guide a class discussion on what a solar still is and what its uses are.

Answers

1. Evaporation
2. When the salt water is heated, the water starts to evaporate, but when it reaches the plastic covering, the water vapour condenses and forms liquid water again. When the water evaporates, the salt remains in the solution in the plastic bowl.
3. The water in the cup is pure water, but the water in the bowl contains salt.
4. Filtration is used to separate an insoluble solid from a liquid. The salt is soluble in water and forms a homogeneous solution.

Activity 7.3: Separation techniques

INDIVIDUAL (SB p.125)

Guidelines

This activity can be done as a class test.

Answers

1. a) A
   b) C
   c) D
   d) B
   e) C
2. a) Filtration
   b) Fractional distillation
   c) Floatation
   d) Evaporation
   e) Paper chromatography
   f) Chromatography
   g) Filtration and evaporation
   h) Filtration

Revision questions: Answers

(SB p. 127)

1. a) Copper metal is an element.
   b) Copper oxide is a compound.
   c) Brass is a homogeneous mixture.
   d) Copper ore is a heterogeneous mixture.
2. a) Pure substance
   b) Mixture
   c) Homogeneous
   d) Distillation
   e) Column chromatography
   f) Fractional distillation
   g) Solvent
   h) Residue
   i) Precipitate
   j) Suspension
3. a) D
   b) A
   c) C
   d) C
   e) D
4. a) i) The substances maintain their chemical and physical properties and they can be separated using mechanical separation techniques.
   ii) It forms a heterogeneous mixture, because the individual substances that compose the mixture can be detected and there are two phases visible in the mixture.
   iii) It is a suspension, because the particles of the solute are evenly dispersed and the suspension settles when left undisturbed for a period of time.
   b) Evaporation or filtration.
5. a) Distillation.
   b) Kemi first heated the iodine–sand mixture. Iodine has a lower melting point and boiling point than sand and will start to evaporate before the sand. When the iodine vapour reaches the top (where the ice is), the vapour condenses to form a liquid. The liquid iodine freezes to form the purple solid iodine.
   c) Iodine
   d) The ice is used to cool the iodine vapour, resulting in condensation.
6. a) Filtration
   b) a: Filter paper
   b: Filtrate
   c: Residue
   d: Filtrate
   c) C, A, D, B
   d) A heterogeneous mixture of an insoluble solid in a liquid can be separated by means of filtration. The solid particles that are suspended in the liquid are collected on the filter paper as the residue and the liquid is collected in the beaker as the filtrate.
   e) A salt-water solution is a homogeneous mixture. Filtration only works with a heterogeneous mixture where a solid is suspended in a liquid.
   f) Students may give various examples of where the filtration method is used in their homes. One example is water filters in homes. Water filters help to remove impurities from the water. The water filter removes the impurities from the water by means of a fine physical barrier, a chemical process or a biological process.
   g) A car air filter is used to filter or clean outside air before it gets sucked into a car engine and burned, along with fuel, to produce combustion. Filtration of the air is necessary to prevent engine contamination.
7. a) b: Salt solution
   c: Water
   b) A Liebig condenser
   c) It depends on what is in the original solution.
   d) It depends on the distillate.
   e) The students may explain distillation or evaporation. Check that their answers are correct.

f) Boiling chips prevent the liquid from becoming superheated and bumping, thus ensuring that the liquid boils smoothly.

8. a) An increase in temperature results in an increase in solubility.
   b) Potassium nitrate
   c) The filtration separation technique was used. The sand is insoluble in water. The mixture was filtered using filter paper and a funnel. The sand residue remained on the filter paper and the filtrated solution contained the potassium nitrate and copper sulphate pentahydrate.
   d) Evaporation
   e) The salt that is the least soluble will crystallise first, thus potassium nitrate will crystallise first.
   f) Fractional crystallisation
9. We can separate a mixture of iron and copper filings by holding a magnet above the mixture. The magnet will attract the iron filings but not the copper.
10. a) Filtration and evaporation
   b) The sand and sodium chloride should first be mixed with water. The mixture must then be filtrated. The sand will be the residue on the filter paper and the sodium chloride solution will be the filtrate. The filtrate must then be allowed to undergo evaporation until all the water has evaporated. The sodium chloride salt crystals will remain.

How are you doing?

Take this opportunity to ask learners if there is anything that they do not understand. You can check their understanding by asking them some questions about the information covered in the unit. Explain anything that learners do not understand.

Key words

alloy – a homogeneous mixture of two or more metals

chromatography – separates the components of a mixture by passing the mixture along a stationary material; different components of the mixture move at different rates and are separated from each other

colloid – a mixture consisting of tiny particles that are homogeneously distributed in the solvent; the particles of the solute can be seen with the naked eye or microscope; do not settle when left standing

crystallisation – used to get a solid from a saturated solution

crystals – homogeneous solid substances that have natural geometrically regular forms

decantation – used to separate an insoluble solid from a liquid by removing a layer of liquid, generally one from which a precipitate has settled

distillation – used to separate mixtures, based on the differences in the volatilities or boiling points of the substances in the mixture

emulsion – a heterogeneous mixture of two or more immiscible liquids in which one liquid is dispersed in the other; settles into layers when it is left standing undisturbed

evaporation – used to separate a soluble solid from a liquid by heating the solution; the liquid leaves the solution and the solid stays behind

filtrate – the clear liquid that filters through the filter paper

filtration – used to separate an insoluble solid from a liquid by collecting the solid particles on a filter

fining – an application of the precipitation process where substances are added at or near the completion of the processing of brewing beer and wine to improve it

floatation – used to separate materials by using their differences in density

fractional crystallisation – a method of separating a mixture of soluble solids by dissolving them in a suitable hot solvent and then allowing it to cool slowly

heterogeneous mixture – the substances do not blend thoroughly and the individual substances that compose the mixture can be detected

homogeneous mixture – the individual parts of the mixture cannot be distinguished from each other

immiscible – cannot be mixed or blended together

impure substance – a mixture; physical combinations of two or more different substances that are not chemically combined

magnetic attraction – substances can be separated from mixtures by using a magnet

precipitate – the solid formed in a reaction

precipitation process – separates a dissolved substance from a solution by chemically converting the dissolved substance to an insoluble solid form

pure substance – consists of only one type of particle; can be either an element or a compound

residue – the solid that remains behind on the filter paper

saturated solution – has the maximum amount of solid dissolved in it (no more of the solid will dissolve in the solution)

simple distillation – the distillation method used to separate substances in mixtures with significantly different boiling points

slurry – a suspension of insoluble material (ground rock) in water

solute – the substance that dissolves in the solvent

solution – a homogenous mixture of two or more substances

solvent – the substance that makes up the larger part of the solution

sublimation – when a solid changes state directly into the gaseous state; separates a mixture of solids, one of which sublimes

suspension – a heterogeneous mixture in which particles of the solute are more or less evenly dispersed throughout a liquid or gas; will settle when left standing undisturbed

volatility – the speed at which a substance changes from liquid to gas form

Checklist for Self-evaluation

Theme 3 Topic 7

EVALUATION GUIDE: Student should be able to:

	Criteria	4	3	2	1	Comments
1	State the principles applied in the separation of mixtures					
2	State different standard methods of separating mixtures					
3	State the criteria for purity					
4	Use appropriate techniques to separate a mixture					

Code for evaluation:			
4 – Very well	3 – Well	2 – Fairly well	1 – Not well at all

Topic 8: Acids, bases and salts

Performance objectives
8.1 Define acids, bases and salts **8.2** Identify acids and bases **8.3** Describe the nature of protons in an aqueous solution **8.4** Explain neutralisation reactions **8.5** Explain how an acid–base indicator works **8.6** Use pH as a scale and discuss the importance of the pH value **8.7** Identify and prepare salts (normal, acidic and basic) **8.8** State properties of salts **8.9** State the rules of solubility in water

Introduction

We can classify many substances that we use in our homes every day as acids or bases. Acids are substances that ionise in water to produce H^+ ions and bases are substances that ionise in water to produce OH^- ions. In this topic we will look at characteristics, preparation methods, different reactions and uses of acids, bases and salts. We will also discuss the relative acidity and alkalinity of substances by comparing them on the pH scale. Deliquescent, efflorescent and hygroscopic substances will be discussed as well as the solubility of different salts in water.

Activity 8.1: Acids and bases

INDIVIDUAL (SB p.139)

Guidelines

This activity can be used as a class test.

Answers

1. a) C
   b) D
   c) A
   d) A
2. a) D
   b) C
   c) A
   d) E
   e) B
   f) F
3. Dilute acids have a sour taste.
   The concentrated form of strong acids is corrosive and will burn your skin.
   All aqueous solutions of acids conduct electricity due to the presence of mobile ions in the solution. Therefore, acids are electrolytes. Electrolytes are solutions that conduct electricity.
   Acids cause colour changes in indicators (plant dyes). For example, litmus paper will turn from blue to red.
4. A base is a compound that tastes bitter and feels soapy between your fingers.
   Bases dissolve in water to form a solution with pH more than 7 and therefore react with indicators to produce predictable changes in colour: Litmus paper turns from red to blue.
   The concentrated form of strong bases is corrosive and will burn your skin.
   Dilute bases are electrolytes, because they split up into mobile ions that conduct electricity.

Experiment 8.1: The reactions of acids with metals

INDIVIDUAL (SB p.141)

Resources

Dilute solutions of HCl and H_2SO_4, Zn, Fe and Mg in granular form (or use an iron nail and a cleaned piece of magnesium ribbon instead of the Fe and Mg in granular form), 6 test tubes, wooden splint

Guidelines

Assist the students to record their results and to write balanced equations for the reactions performed.

Experiment 8.2: The reactions of acids with metal oxides

INDIVIDUAL (SB p.142)

Resources

Dilute solutions of HCl and HNO_3, MgO and CuO powder, 2 test tubes, beaker, tripod and wire gauze, Bunsen burner, glass rod

Guidelines

Assist the students to record their results and write balanced equations for the reactions performed.

Experiment 8.3: The reactions of acids with metal carbonates

INDIVIDUAL (SB p.142)

Resources

Dilute solutions of HCl and HNO_3, $CaCO_3$ and Na_2CO_3 powder, clear limewater (Ca(OH)2(*aq*)), 4 test tubes

Guidelines

Assist the students to record their results and write balanced equations for the reactions performed.

Activity 8.2: Acids, bases and salts

INDIVIDUAL (SB p.145)

Guidelines

Guide a class discussion on the different types of salts that the students would use in their everyday life. Encourage a discussion around the uses of salts besides seasoning food.

Students should be able to prepare salts by neutralisation reactions (NaC1, $CuSO_4$).

Answers

1. a) A
   b) C
   c) D
   d) B
   e) A
2. a) Sodium carbonate and hydrochloric acid
   b) Sodium chloride, water and carbon dioxide
   c) $Na_2CO_3(aq) + 2HCl(aq) \rightarrow 2NaCl + H_2O + CO_2$
   d) Neutralisation reaction
3. a) $K_2CO_3 + H_2SO_4 \rightarrow K_2SO_4 + H_2O + CO_2$
   b) $Mg(OH)_2 + H_2SO_4 \rightarrow MgSO_4 + 2H_2O$
   c) $Na_2O + 2HNO_3 \rightarrow 2NaNO_3 + H_2O$
   d) $KHCO_3 + HNO_3 \rightarrow KNO_3 + H_2O + CO_2$

Experiment 8.4: Make your own Indicator

(SB p.147)

Resources

Large beaker or pot, distilled water, knife, heat source (Bunsen burner, spirit lamp or stove plate), tripod and wire gauze, test tubes in a test-tube rack, medicine dropper, dilute battery acid, dilute caustic soda, any one of the following brightly coloured flowers or leaves: hibiscus, croton, ixora, allamanda, bluebells

Guidelines

Make the students aware that it is NOT safe to taste any chemical(s) to classify it as an acid or a base.

You can show the students a much safer way is to rather use an indicator, such as a plant or flower extract that will change colour as the pH changes. This experiment will assist to classify substances as acids or bases according to the colour of indicators added to the solution of each substance.

Guide the students to prepare coloured extracts from the flowers as indicators.

Note: Advise the students NOT to discard the indicator solution as they will use it again in Experiment 8.6.

Students should be able to identify acids and bases using the prepared flower extracts as indicators, and explain how an acid-base indicator works.

Experiment 8.5: Colours of laboratory indicators

(SB p.148)

Resources

3 test tubes in a test-tube rack, medicine dropper, distilled water, dilute battery acid, dilute caustic soda, methyl orange, bromothymol blue, phenolphthalein

Guidelines

Students should be able to record their results in a table format.

Students should be able to identify acids and bases using laboratory indicators (methyl orange, phenolphthalein).

Experiment 8.6: Investigate the colour of universal indicator and a plant extract in substances (SB p.149)

Resources

Test tubes in a test-tube rack, glass containers, universal indicator liquid or paper with a colour chart, the plant extract you made in Experiment 8.4, vinegar, lime juice, tap water, rainwater, tea, coffee, milk, fizzy soft drink, antacid, shampoo, soap bar, bicarbonate of soda, salt water, sugar water, liquid soap, dilute car battery acid, washing powder dissolved in water

Guidelines

Assist the students to establish a pH scale and to record their results in a table format like the example provided in the experiment instructions on p.149 of the *Student's Book*. Students should be able to determine the colour of universal indicator in substances.

Experiment 8.7: Neutralise a base using an acid (SB p.151)

Resources

Conical flask, 100 ml measuring cylinders, dilute sodium hydroxide, dilute hydrochloric acid, universal indicator paper strips, dropper

Guidelines

Remind the students that the dilution processes are very exothermic and the solutions will get hot. Always add a concentrated acid slowly to water and allow the solution to cool down in between additions. Never add water to an acid.

Students should never dilute hydrochloric acid themselves as acids react strongly with water.

Students should be able to neutralise sodium hydroxide using hydrochloric acid.

Experiment 8.8: Recover the salt (sodium chloride)

(SB p.152)

Resources

Neutralised solution from Experiment 8.7, evaporating dish, tripod with wire gauze, heat source (Bunsen burner or spirit burner)

Guidelines

The choice of apparatus for this experiment depends on what resources are available at your school. If you have a large class and find it easier to work in large groups, then the neutralisation can be done in glass beakers. If you prefer to have the class work in pairs, then using test tubes for the neutralisation would work better.

Students should be able to recover the salt (sodium chloride) from the solution using evaporation.

Answers

1. Acid + base → salt + water
2. pH > 7
3. The pH decreases, because you are adding an acid with a pH < 7.
4. pH $= 7$ when the solution is neutralised.
5. Hydrochloric acid + sodium hydroxide → sodium chloride + water
6. The white crystals that formed are sodium chloride.

Activity 8.3: Relative acidity and alkalinity INDIVIDUAL (SB p.152)

Guidelines

This activity can be done as a class test. This activity is based on all experiments and activities done so far.

Answers

1. a) D
   b) C
   c) A
   d) D
   e) A

2. A universal indicator is a solution that undergoes several colour changes over a wide range of pH.
3. a) Strong acid
   b) Weak acid
   c) Weak base
   d) Strong base
4. a) pH < 7
   b) pH > 7
   c) pH = 7
   d) pH = 7
5. a) $Mg(NO_3)_2$
   b) CH_3COOK
   c) KNO_3
   d) $(CH_3COO)_2Mg$
6. a) D
   b) C
   c) B
   d) A
   e) E
7. a) Baking soda is basic.

Indicator	Baking soda
Hibiscus flowers	Brown
Cassava leaves	Dark green
Red cabbage leaves	Red

   b) Vinegar is acidic.

Indicator	Vinegar
Hibiscus flowers	Red
Cassava leaves	Yellow
Red cabbage leaves	Green

   c) Hand soap is basic.

Indicator	Hand soap
Hibiscus flowers	Brown
Cassava leaves	Dark green
Red cabbage leaves	Red

   d) Orange juice is acidic

Indicator	Orange juice
Hibiscus flowers	Red
Cassava leaves	Yellow
Red cabbage leaves	Green

Experiment 8.9: Deliquescent, efflorescent and hygroscopic substances (SB p.155)

Resources

Watch glasses, sodium phosphate, copper(II) sulphate crystals, sodium hydroxide, balance

Answers

1. Deliquescent compounds are compounds that, when exposed to air, will absorb moisture and dissolve in it to form a solution.
   Efflorescent compounds are hydrated salts that lose part or all of their water of crystallisation to form a lower hydrate salt when it is exposed to air.
   Hygroscopic compounds absorb water from their surroundings, but will not dissolve in it and will only become sticky.
2. a) Hygroscopic
   b) Efflorescent
   c) Deliquescent

Experiment 8.10: Investigating the solubility of salts (SB p.157)

Resources

Spot-test tile or test tubes, dropper, solutions of these salts for Group 1:
sodium chloride (NaCl), sodium bromide (NaBr), sodium iodide (NaI), sodium carbonate (Na_2CO_3) and sodium nitrate ($NaNO_3$); solutions of these salts for Group 2: sodium sulphate (Na_2SO_4), magnesium sulphate ($MgSO_4$), sodium carbonate (Na_2CO_3), sodium chloride (NaCl) and

sodium nitrate ($NaNO_3$); solutions to be added to the above groups: silver nitrate ($AgNO_3$) and barium nitrate ($Ba(NO_3)_2$)

Guidelines

Students should be able to present their results in a table format such as the example shown in the experiment instructions on p. 157 of the *Student's Book*.

Revision questions: Answers

(SB p. 158)

1. a) A
   b) A
   c) D
   d) C
   e) A
2. a) D
   b) C
   c) B
   d) E
   e) A
3. Dilute acids have a sour taste.
   The concentrated form of strong acids is corrosive and will burn your skin.
   All aqueous solutions of acids conduct electricity due to the presence of mobile ions in the solution. Therefore, acids are electrolytes. Electrolytes are solutions that conduct electricity.
   Acids cause colour changes in indicators (plant dyes). For example, litmus paper will turn from blue to red.
4. a) A Brønsted-Lowry acid is a proton donor.
   b) A Brønsted-Lowry base is a proton acceptor.
   c) $HCl + H_2O \rightarrow Cl^- + H_3O^+$
   d) $Mg(OH)_2 + 2HCl \rightarrow MgCl_2 + 2H_2O$
5. a) Zinc chloride ($ZnCl_2$)
   b) Copper(II) sulphate ($CuSO_4$)
   c) Sodium nitrate ($NaNO_3$)
6. Solution A has more hydrogen ions in solution, because an acid produces hydrogen ions in solution. Solution A is acidic and solution B is basic.
7. pH measurements are important in chemistry, agriculture, civil and chemical engineering, environmental science, biology, medicine, water treatment and purification.
   - Most plants grow well in neutral soil but grow poorly in soil with a very high or very low pH. A gardener sometimes needs to know the pH of the soil to determine if certain plants can grow in it.
   - The pH plays a big role in maintaining the neutral status of the stomach. To neutralise the stomach, bases are taken externally in the form of tablets (antacids) and syrups. These bases are diluted alkaline suspensions, such as milk of magnesia.
   - Once food is taken into the mouth, the bacteria in the mouth start to break down some of the food particles and acids are produced in the process that can lead to teeth decay.
   - A fluctuation in the pH of the blood can cause serious harm to vital organs in the body, so testing can help.
   - The pH is one of many factors that are tested in a swimming pool. Acidic or basic chemicals can be added if the water becomes too acidic or too basic.
8. a) Deliquescents are compounds that, when exposed to the atmosphere, absorb moisture and dissolve in it to form solutions. Examples are: sodium hydroxide pellets, iron(III) chloride, phosphorous(V) oxide, potassium hydroxide and calcium chloride.
   b) Efflorescent compounds are hydrated compounds that lose part or all of their water of crystallisation to form lower hydrated salts when exposed to the atmosphere.
   Hygroscopic compounds are compounds that, when exposed to the atmosphere, absorb water from the surroundings and become sticky, but do not dissolve in it.
   c) Place some washing soda and calcium chloride in two separate watch glasses and leave them exposed to air. Observe the properties of the initial salts. After a few minutes observe what happens to the salts. If either is a deliquescent compound, when it is exposed to the atmosphere, it will absorb moisture and dissolve in it to form a solution. If either is an efflorescent compound,

it will lose part or all of its water of crystallisation to form lower hydrated salts when exposed to the atmosphere. If either is a hygroscopic compound, when it is exposed to the atmosphere, it will absorb water from the surroundings and become sticky, but it will not dissolve in it.

9. a) Soluble
   b) Insoluble
   c) Insoluble
   d) Soluble
   e) Soluble

How are you doing?

Take this opportunity to ask learners if there is anything that they do not understand. You can check their understanding by asking them some questions about the information covered in the unit. Explain anything that learners do not understand.

Key words

acid – a substance that produces hydrogen ions in a water solution

alkali – a base that is soluble in water

Arrhenius' theory – acids are substances that, when dissolved in water, produce hydrogen ions (H^+) and bases are substances that produce hydroxide ions (OH^-) in water solutions

base – produces hydroxide ions (OH^-) when dissolved in water

Brønsted-Lowry theory – an acid is a substance that donates a proton (H^+ ion) in a reaction and a base is a substance that accepts a proton (H^+ ion) in a reaction

catalyst – a substance that speeds up a reaction without itself taking part in the reaction

concentration – a ratio of the amount of solute to the volume of solvent in a solution

deliquescent compounds – compounds that, when exposed to the atmosphere, will absorb moisture and dissolve in it to form solutions

dilute – when an acid or base is added to water so that it is present in a small proportion

dissociation – the process whereby ionic compounds break up into their separate ions in the presence of water

efflorescent compounds – hydrated salts that lose part or all their water of crystallisation to form a lower hydrate salt when exposed to the atmosphere

electrolytes – solutions that conduct electricity

hydrate – a salt created when some ionic crystals trap water molecules between their ions when it forms

hydrolysis – the ability of ions to react with the water molecules and in the process alter the pH of the solution

hygroscopic hydrates – compounds that, when exposed to the atmosphere, will absorb water from the surroundings, but will not dissolve in it and will only become sticky

neutralisation reaction – when an acid is added to a base, the acid loses its acidic properties and the base loses its basic properties

pH scale – used to measure how acidic or basic a substance is; the pH scale runs from 0 to 14

strong acid – an acid that ionises completely in water to form $H^+(aq)$ ions

strong base – a base that completely dissociates in water to form $OH^-(aq)$ ions

volatile – a substance that easily evaporates at normal temperatures

weak acids – ionise only partially in water to form $H^+(aq)$ ions

weak base – a base that dissociates partially in water to form OH^- ions

Checklist for Self-evaluation

Theme 3 Topic 8

EVALUATION GUIDE: Student should be able to:

	Criteria	4	3	2	1	Comments
1	Mention some common acids and bases					
2	List the characteristics of acids, bases					
3	List the different types of salts					
4	Distinguish between the various places where the knowledge of pH value is put to use					
5	Prepare salts by neutralisation reactions, e.g. NaCl, $CuSO_4$					

Code for evaluation:			
4 – Very well	3 – Well	2 – Fairly well	1 – Not well at all

Topic 9: Water

Performance objectives

9.1 State sources of water
9.2 State the properties of water
9.3 Describe the laboratory preparation of water
9.4 Distinguish between soft and hard water
9.5 Define pollution and list some water pollutants
9.6 State the uses of water
9.7 Describe the procedure for the laboratory preparation of water

Introduction

Water is the most common substance on the surface of Earth and is found in all three phases: water vapour is a gas, water is a liquid and ice is a solid. Although there are many sources of water, only a tiny fraction of the total amount of water is available for human use. The different uses of water are discussed in this topic. This topic also deals with the properties of water and how it can be prepared in the laboratory. We also distinguish between soft and hard water. Pollution of water is discussed.

Activity 9.1: Sources of water

INDIVIDUAL (SB p.163)

Answers

1. a) Transpiration
   b) Evaporation
   c) Condensation
   d) Precipitation
   e) Infiltration and percolation
2. 97% of the water on Earth can be found in the oceans. Most of the fresh water on Earth can be found in the glaciers and icecaps. The water available to humans can be found in rainwater, springs, streams, rivers and lakes.
3. Solid, as ice; liquid as water; gas as water vapour
4. Most of the water is in the seas and too salty to use directly. The fresh water is mostly frozen in glaciers in the ice caps. Only a very small part is fresh liquid water that we can use.

Activity 9.2: Properties of water

GROUP/CLASS (SB p.166)

Answers

1. a) The oxygen atom has a stronger pull on the shared electron pairs, resulting in the oxygen side of the molecule being slightly negative and the hydrogen side being slightly positive. Two poles form and the water molecule is a dipole.
   b) Hydrogen bonds between water molecules make water a liquid at ambient temperatures. Life is dependent on water in the liquid state. The polar molecule can absorb sunlight very well and this helps to moderate the temperatures on Earth.
2. Life as we know it is water-based. Living organisms utilise the fact that water is a liquid at ambient temperatures in their circulatory systems. For example, blood is made up of water and contains and transports a variety of chemicals through animal bodies. Plants use water to transport chemicals between their roots, leaves and flowers. Climate is also determined by water in the atmosphere, and life is dependent on favourable climatic conditions.
3. A lot of energy is required to break the many hydrogen bonds between water molecules to increase its temperature and change its phase. Water acts as a heat reservoir.
4. To increase the rate of evaporation
   – increase the exposed surface area
   – increase the temperature

- increase the flow of air across the surface
- decrease the air pressure exerted on the surface.

5. a) Surface tension
   b) Water molecules at the surface attract other molecules sideways and downwards. The result is the formation of an elastic film on the surface of the water.
6. a) Capillarity
   b) There are narrow spaces between the fibres that act as tubes for the water to creep up under capillary action. The water is absorbed into the nappy fibres away from the baby's bottom.
7. When somebody is exposed to cold water, the body loses heat to the water. The condition where the body temperature is below normal is called hypothermia and can kill a person if the temperature is not increased in time. Water from the wet skin will continue to evaporate and cause the body temperature to drop further. Dry him as far as possible and then wrap him in a thermal insulator that can preserve his body temperature, such as a blanket. The body is able to produce its own heat and you only have to make sure that the heat stays where it is needed. Give the person a warm, sweet drink, like tea, to increase his blood sugar level. The body can break down sugar to release energy.
8. Water can wet the surface of glass and porcelain. A cloth or sponge also absorbs water as a result of capillarity. The wet cloth can remove dirt from our bodies and also from our plates and dishes. Oily substances do not dissolve in water and it is difficult to clean surfaces that have oily deposits on them. Oily substances are hydrophobic (hate water). Detergent and soap consists of large molecules. The one side of the molecule is hydrophilic (love water) and can dissolve in water and the other side is hydrophobic and can dissolve in oil. The detergent acts as a go-between and makes it possible to remove fatty substances from our bodies and from our dishes.

Experiment 9.1: Investigating water

(SB p.168)

Resources

A range of water samples, for example, from a tap at school, a nearby river, a dam, a well point, a borehole or the sea, magnifying glass or microscope, funnel and filter paper, pH meter or universal indicator strips, silver nitrate, concentrated nitric acid, water test kit (if available)

Guidelines

Guide a class discussion on how to distinguish between pure and impure water samples based on colour and odour.

Students should be able to investigate and compare different samples of water, and record their results.

Activity 9.3: Types of water

INDIVIDUAL (SB p.169)

Resources

Samples of hard water, soap

Guidelines

Guide a class discussion on the different types of water.

Students should be able to list the types of water, and be able to distinguish between hard and soft water.

Answers

1. Hard water and soft water
2. Soft water stored in granite or sandstone; hard water stored in limestone and chalk
3. Calcium and magnesium ions
4. When acidic rainwater moves through the soil, it dissolves limestone to release calcium and magnesium ions.
5. Calcium hydrogen carbonate and magnesium hydrogen carbonate
6. The hardness can be reduced by boiling the water.
7. Calcium sulphate ($CaSO_4$) and/or magnesium sulphate ($MgSO_4$)
8. Send the water through an ion exchange column.

9. Positive: It contains a lot of dissolved minerals that the body needs.
   Negative: It does not taste very nice. Hard water deposits calcium carbonate or limescale that builds up in pipes, boilers and kettles. It can block pipes and reduce efficiency of kettles and boilers.
   Soap does not form a lather with hard water, but soap scum that makes it difficult to wash dishes and clothes.

Activity 9.4: Investigating water quality

INDIVIDUAL (SB p.171)

Answers

1. Malaria is transmitted by the Anopheles mosquito. When the female mosquito bites a person with malaria, she draws up a small amount of the infected blood. The malarial parasites then pass through several stages of development within the mosquito's body, and finally find their way to the mosquito's salivary glands. There they lie in wait for the opportunity to enter the blood stream of their next victim. The parasite infects the red blood cells of the person and multiplies there.
2. Mosquitoes breed in stagnant water. Swamps and marshes can be treated with chemicals to kill the mosquito larvae, but the chemicals will also kill other useful water life. Water surfaces can also be sprayed with detergent. The soap breaks the surface tension of the water so the mosquito larvae cannot breathe. The best method to protect yourself against the disease is to wear protective clothing at night, when mosquitoes are more active. Apply insect repellent onto the skin to ward off the mosquitoes. A mosquito net over the bed will also keep them at bay.
3. Find out in advance if clean, treated water will be available. It is always safe to take commercially manufactured chlorine tablets along. Do not swim or wash in water where there might be bilharzia pollution.
4. Use any of the following factors that are applicable to your area: sewage, agriculture, industry or oil spillage.

Activity 9.5: Investigate the uses of water

INDIVIDUAL (SB p.174)

Guidelines

This activity is designed to make the students aware of how much we need water in our daily lives, how important it is that the water is not polluted and how precious water is.

Guide a class discussion about these issues.

Experiment 9.2: Preparing water in the laboratory

(SB p.174)

Resources

zinc granules or powder (Zn), dilute hydrochloric acid (HCl), spatula, test-tube in test tube stand, ball of cotton wool, wooden splint, matches, anhydrous copper(II) sulphate, watch glass, small pipette

Revision questions: Answers

(SB p. 127)

1. a) C
   b) A
   c) C
   d) D
   e) B
   f) A
2. a) Water cycle
   b) Groundwater
   c) Natural water sources
   d) Hydrogen bonds
   e) Water pollution
   f) Sewage
   g) Hard water
3. a) A: Evaporation
   B: Transpiration
   C: Condensation
   D: Precipitation
4. a) The water is not polluted close to its origin where no humans live.
   b) The power station uses water from the river for cooling and pumps hot water back into the river.
   c) The effluent water from the fertiliser factory contains some nutrients and the water plants will grow fast.
   d) The water plants use up all the oxygen in the water and there is no oxygen left for the fish to breathe.
5. a) The water is pure and clean.
   b) From a clean water source like a spring.
   c) Through distillation: pour water in a distillation flask and heat the water. Cool the water vapour that boils off by passing it through a condenser. Collect the distilled water in a clean container.
   d) In a laboratory
   e) Bottled water contains minerals but no contaminants; distilled water contains no minerals.
   f) No, distilled water contains no minerals and our bodies need minerals for healthy growth.
6. a) Hard water
   b) Formation of lime scale in water pipes, kettles and boilers
   Formation of scum with soap
   c) Soft water
   d) Temporary hard water: boiling
   Permanent hard water: ion exchange

How are you doing?

Take this opportunity to ask learners if there is anything that they do not understand. You can check their understanding by asking them some questions about the information covered in the unit. Explain anything that learners do not understand.

Key words

adhesion – force of attraction between different types of molecules that binds a substance to a surface
anhydrous – without water
aquifers – layers of soil or rock that can hold or filter a lot of water
capillarity – the upward creep (movement) of water in a narrow tube
cohesion – force of attraction between molecules of the same type within a substance
de-ionisation – process of removing ions from water by using an ion-exchange resin
dipoles – molecules with two poles: a slightly negative and a positive side
electronegativity – the ability of an atom in a molecule to attract the bonding electron pair
hard water – water with high concentrations of dissolved ions, in particular calcium and magnesium ions
heat capacity – the amount of heat required to raise the temperature by 1 °C
hydrophilic – substances to which water molecules are attracted

infiltration – rainwater that seeps through the ground
meniscus – the curved surface of a liquid in a tube; caused by adhesion between the liquid and the glass
pathogens – micro-organisms that cause diseases
percolation – movement of water through underground porous rock and soil
polarity – the difference in charges on molecules
precipitation (water cycle) – when tiny droplets of water pack together and fall to the ground as rain
sedimentation – when solid particles in suspension settle out
sewage – waste water and excrement
soft water – has low concentrations of ions in solution and soap lathers easily in it
surface tension – the elastic surface film that forms as a result of sideways and downward cohesion forces
transpiration – water that evaporates from the leaves of plants
water cycle – the movement of water around Earth through evaporation, transpiration, condensation, precipitation, infiltration and percolation

Checklist for Self-evaluation

Theme 3 Topic 9

EVALUATION GUIDE: Student should be able to:

	Criteria	4	3	2	1	Comments
1	State the properties of water					
2	List the types of water					
3	Describe the laboratory preparation of water					
4	Mention some water pollutants					
5	State the uses of water					

Code for evaluation:			
4 – Very well	3 – Well	2 – Fairly well	1 – Not well at all

THEME 4

The chemistry of life

Topic 10: Carbon and its compounds
Performance objectives
10.1 Identify various substances in and around us that contain carbon **10.2** Describe the unique characteristics of carbon as an element **10.3** Explain the relationship between the structure of carbon and the existence of many natural and synthetic carbon-containing compounds **10.4** Infer that a large percentage of world energy needs depend on carbon-containing compounds like coal, coke and petroleum **10.5** Define the term 'allotrope' **10.6** Show that carbon forms two types of oxide, both of which are important economically **10.7** Identify carbon(IV) oxide

Introduction

Earth's crust only contains about 0.09% carbon by mass, but carbon is an essential element of all living matter. It is found free in the form of diamond and graphite and it is also a component of the fossil fuels, such as natural gas, crude oil and coal. Carbon combines with oxygen to form carbon dioxide in the atmosphere and occurs as carbonate in limestone and dolomite. The versatility of the element carbon is responsible for the millions of organic compounds found on Earth.

Activity 10.1: Carbon INDIVIDUAL (SB p.182)

Answers

1. Wood, cotton and paper contain cellulose; wool contains keratin, which is a protein; nylon is a polyamide polymer; polyester in fabric and plastic cooldrink and water bottles is made of polyethylene terephthalate; rubber contains polyisoprene; plastics are mostly polyethylene, polypropylene and polyvinylchloride (PVC); living organisms contain proteins, carbohydrates – sugars and starches, nucleic acids, lipids – fats, oils and waxes
   Inorganic carbon compounds include graphite, diamond, carbon dioxide, carbon monoxide, carbonic acid, various carbonates, such as calcium carbonate in limestone, chalk and marble, baking soda ($NaHCO_3$), etc.
   Products from fossil fuels, such as coal, crude oil, natural gas, kerosene, diesel, tar, waxes, petrol
2. All the items contain carbon.
3. Green plants use carbon dioxide, an inorganic compound, to make glucose, an organic compound, through the process of photosynthesis.
   $$6CO_2 + 6H_2O \rightarrow C_6H_{12}O_6 + 6O_2$$
   Glucose is the basic food molecule of living organisms.
   Living organisms break down glucose during respiration to provide in their energy needs. In this process, carbon dioxide is returned to the atmosphere.
   $$C_6H_{12}O_6 + 6O_2 \rightarrow 6CO_2 + 6H_2O$$
4. Organic chemistry
5. Carbon can make four covalent bonds to other carbon atoms and also to many other atoms to form a large range of compounds.

6. a) A green tree photosynthesises when the sun shines on its leaves. It converts CO_2 to glucose, which is stored in the cells of the tree. The plant cells also respire to provide in its own energy needs. The cells break down the glucose and CO_2 is returned to the atmosphere.
   b) A goat eats grass and other vegetation. His body breaks down the plant material to release the food molecules. During respiration his cells break down the glucose to provide energy and he breathes out CO_2.
   c) Bacteria use decaying materials as food and they respire to release CO_2 to the atmosphere.
7. Natural polymers, for example, rubber
   Synthetic polymers, for example, plastics
   Biological polymers, for example, proteins

Experiment 10.1: Adsorption of carbon (SB p.185)

Resources

100 ml glass beakers (one for each type of carbon being tested and one more), 250 ml glass beaker, red food colouring, water, various types of carbon, such as activated carbon, charcoal, coke, coal, graphite

Guidelines

This experiment can be used to explain the adsorption efficiency of different types of carbon. The different types of carbon will discolour the solution depending on their adsorption efficiency. The clearer the solution becomes, the better the adsorption of the carbon.

Activity 10.2: Allotropes of carbon

INDIVIDUAL (SB p.185)

Answers

1. Diamond, graphite, amorphous carbon, graphene, fullerenes
2. a) Carbon atoms are covalently bonded to form hexagonal rings that pack in layers that are held together by weak Van der Waals' forces. The layers can slide over one another when the Van der Waals' forces are broken.
   b) The electrons that do not take part in covalent bonding form a sea of delocalised electrons that are able to conduct electricity.
3. Carbon black: pigment in printing ink
   Charcoal: fuel to provide heat
   Activated carbon: removal of contaminants from air and water
   Coke: Reduction of iron ore

Experiment 10.2: Composition of coal (SB p.187)

Resources

2 test tubes with stoppers, glass delivery tubes (refer to apparatus diagram), Bunsen burner, powdered coal, retort stand, water

Activity 10.3: Coal INDIVIDUAL (SB p.187)

Answers

1. Lignite, lowest quality; binuminous coal, medium quality; anthracite, highest quality
2. a) Destructive distillation of coal
   b) Coke, coal tar, ammonia, sulphur dioxide, coal gas

Experiment 10.3: Properties of carbon dioxide INDIVIDUAL (SB p.190)

Resources

Baking soda, white vinegar, small candle (tea-light), glass beaker, wooden splint, universal indicator, ammonia solution or dilute sodium hydroxide solution, conical flasks, one with a narrow mouth, balloon, delivery tube or rubber tube

Answers

1. Oxygen is necessary for any burning to take place, while carbon dioxide does not support combustion. The flame of the splint will go out.
2. For the extinguisher, use a plastic drink bottle. Drill a small hole into the screw top. Place a small amount of baking soda in the bottom of the plastic drink bottle.

Add a small amount of vinegar to the container. To initiate the extinguisher, tip the bottle to start the reaction, and the carbon dioxide will form.

3. Fizzy drinks contain carbon dioxide dissolved in water. Carbonic acid forms, which is an acid.

Activity 10.4: Limestone and its products
INDIVIDUAL (SB p. 194)

Answers

1. Chalk is softer than limestone.
2. Marble is the hardest.
3. Limestone is abundant and rural people could find enough limestone in most areas. Limestone is relatively soft and brittle and can be cut into blocks and slabs that make it easy to build with.
4. A kiln is an oven that can withstand very high temperatures and that is used to melt metals and minerals and bake earthenware and ceramics.
5. (*aq*) means aqua: calcium hydroxide is dissolved in water
6. $CaCO_3(s) \rightarrow CaO(s) + CO_2(g)$
   $CaO(s) + H_2O(l) \rightarrow Ca(OH)_2(s)$
   $CO_2(g) + Ca(OH)_2(aq) \rightarrow CaCO_3(s) + H_2O(l)$
7. Calcium carbonate: $CaCO_3$
8. Reinforced concrete is used in all large structures and foundations for large structures, such as multi-storey buildings and bridges.
9. Steps, foundations, floors, decking, roads and paths, etc.
10. In clay soil the soil particles are very small and pack tightly together. They trap and retain water molecules. Slaked lime breaks up the clay soil, makes it less ‘sticky’ and neutralises the acids.
11. Impurities weaken the iron. Iron is used mainly for its strength and impurities will undermine its strength.
12. A personal choice. Here are a few examples:
    – Cement and concrete are used to build houses.
    – Slaked lime improves soil so that crops can grow better.
    – Iron is used in all structures that need to be strong and tough; glass and glass products are used in the construction of homes and other buildings, cars and kitchenware.
    – Without paper this book would not have existed.

Experiment 10.4: Reaction of a carbonate with an acid
(SB p.195)

Resources

2 test tubes in a test-tube stand, spoon spatula, chalk dust, limewater, dilute hydrochloric acid

Guidelines

When carbonate reacts with acid, salt, water and carbon dioxide are produced. This is a neutralisation reaction. A test for carbon dioxide is to bubble it through clear limewater, which will turn milky in the presence of carbon dioxide.

Answers

1. acid + carbonate → salt + water + carbon dioxide
2. Large bubbles form when acid is added to the chalk dust.
3. Place a stopper with a delivery tube in the mouth of the test tube. The gas moves through the delivery tube and can be collected and tested.
4. The gas is probably carbon dioxide. Bubble the gas through clear limewater. If it turns milky, you know the gas is carbon dioxide.

Experiment 10.5: Decomposition of a carbonate
(SB p.196)

Resources

2 test tubes, spatula, retort stand and clamp, stopper with delivery tube, Bunsen burner, copper(II) carbonate powder, limewater

Answers

1. a) Collect any gas that is liberated and bubble it through clear limewater. If the limewater turns milky, the zinc carbonate decomposed to form carbon dioxide as one of the products.
   b) $ZnCO_3(s) \rightarrow ZnO(s) + CO_2(g)$

Activity 10.5: Hydrocarbons

INDIVIDUAL (SB p.199)

Answers

Name	Number of carbon atoms	Single, double or triple bonds
Ethane	2	Single
Propyne	3	Triple
Butene	4	Double
Benzene	6	Double
Pentyne	5	Triple
Octane	8	Single

Activity 10.6: Crude oil and natural gas

INDIVIDUAL (SB p.200)

Answers

1. Gold is a valuable and precious metal that earns a lot of foreign currency for the countries that mine it. Crude oil is also a valuable commodity that earns foreign revenue for countries such as Nigeria that have oil fields that can be exploited.
2. Crude oil is a mixture of many different hydrocarbons and impurities. Each group of hydrocarbons has a different use. To use crude oil effectively, the fractions in crude oil must be separated in a refinery.
3. The base of the column is hot and the coolest part is at the top of the column. At the base most of the oil boils and the vapour rises up the column. As the vapour moves up the tower, the temperature decreases, and when the condensation point of a certain fraction of chemicals is reached, that fraction condenses in a tray and is removed from the vapour. The rest of the oil that is still in vapour form rises up to the next level where the next fraction condenses, and so on. The many levels of the fractionating tower separate the oil into many fractions.
4. a) Fuel gas and cooking gas
   b) Petrol and organic solvents
   c) Jet engine fuel and domestic heating
   d) Diesel fuel and feedstock for catalytic cracking
   e) Lubricating oils, waxes and bitumen

Revision questions: Answers

(SB p. 202)

1. a) D
   b) D
   c) A
   d) C
   e) B
   f) D
2.

Column A	Column B
a) Allotrope of carbon	E Lignite
b) Class of coal	C Graphite
c) Product of destructive distillation of coal	A Coke
d) Dissolve in water to make carbonic acid	B Carbon dioxide
e) The group of compounds that react with an acid to liberate CO_2	D Carbonates

3. a) Organic chemistry
   b) Allotropy/ allotropes
   c) Diamond
   d) Global warming
   e) Aromatic hydrocarbons/ arenes
   f) Methane
4. A: combustion; B: respiration; C: photosynthesis
5. a) Red
   b) The pH will increase
   c) When all the acid has been neutralised, the solution will have a pH of 7.
   d) The ions in the acid react with the ions in the base to form water, which is a neutral compound. The baking soda 'cancels' the acidic properties of the vinegar.
   e) $NaHCO_3(s) + CH_3COOH(aq) \rightarrow CH_3COONa(aq) + H2O(l) + CO_2(g)$
6. a) Limestone/ chalk/ marble
   b) $CaCO_3(s) \rightarrow CaO(s) + CO_2(g)$
   c) Calcium hydroxide, $Ca(OH)_2$
   d) Calcium carbonate, $CaCO_3$
   e) Carbon dioxide, CO_2
7. a) Propene
   b) Ethyne
   c) Benzene
   d) Methane
8. a) Coal, crude oil and natural gas
   b) Fossil fuels are the remains of plants and animals that lived millions of years ago. It took all that time to form the fossil fuels. When we use up the fossil fuels, there is no way to create a further supply.
   c) When trees that lived millions of years ago died, they fell into swamps where there was insufficient oxygen for them to decay completely. Layers of vegetation built up on the half-rotten trees and increased the pressure on them. After millions of years of compression, the trees turned into coal. Oil and gas were formed when sea plankton were compressed.
   d) Photosynthesis
   e) When the fossil fuels are combusted, the chemical bonds between the C and H atoms break and energy is released.
   f) Oxygen
9. a) Fractional distillation column/ fractionating tower
   b) Fractional distillation
   c) Differences in boiling point
   d) i) A
      ii) E
      iii) B
      iv) E
      v) D
      vi) B
      vii) E
      viii) C

How are you doing?

Take this opportunity to ask learners if there is anything that they do not understand. You can check their understanding by asking them some questions about the information covered in the unit. Explain anything that learners do not understand.

Key words

adsorption – the adhesion of particles (atoms, ions or molecules) onto the surface of another material

alkane – hydrocarbon with single bonds between the carbon atoms; saturated

alkene – hydrocarbon with at least one double bond between two carbon atoms; unsaturated

alkyne – hydrocarbon that contain a -C≡C- triple bond

allotrope – chemical elements that exist in two or more different molecular or crystalline forms while in the same physical state

amorphous carbon – carbon in which the atoms have no crystalline structure; examples are charcoal, soot, activated carbon and carbon black

arene – hydrocarbon that have at least one aromatic ring (benzene ring); have distinctive, usually pleasant smells

carbon cycle – the path of carbon as it is transferred from living organisms to non-living forms through the processes of photosynthesis and respiration; the main compound in the cycle is carbon dioxide

cycloalkane – hydrocarbon containing one or more carbon rings to which hydrogen atoms are attached

destructive distillation – the process of breaking up large molecules in coal by heating it in the absence of air

hydrocarbon – the simplest organic compound; contains only carbon and hydrogen atoms; can be straight-chained, branched or cyclic molecules

organic chemistry – the study of carbon compounds

photosynthesis – the process in which green plants synthesise glucose from carbon dioxide and water in the presence of sunlight

polymers – very large molecules (macromolecules) that contain hundreds to thousands of atoms

synthesis gas (synthetic gas or syngas) – a mixture of mainly of hydrogen and carbon monoxide with some CO_2 and other impurities; usually a product of gasification and used to generate electricity

Checklist for Self-evaluation

Theme 4 Topic 10

EVALUATION GUIDE: Student should be able to:

	Criteria	4	3	2	1	Comments
1	Identify various substances that contain carbon					
2	Describe the unique characteristics of carbon					
3	Explain the relationship between the structure of carbon and the existence of many natural and synthetic carbon-containing compounds					
4	Describe the allotropes of carbon					
5	Show that carbon forms two types of oxide					
6	Show that the world energy needs are dependent on carbon-containing compounds					

Code for evaluation:			
4 – Very well	3 – Well	2 – Fairly well	1 – Not well at all