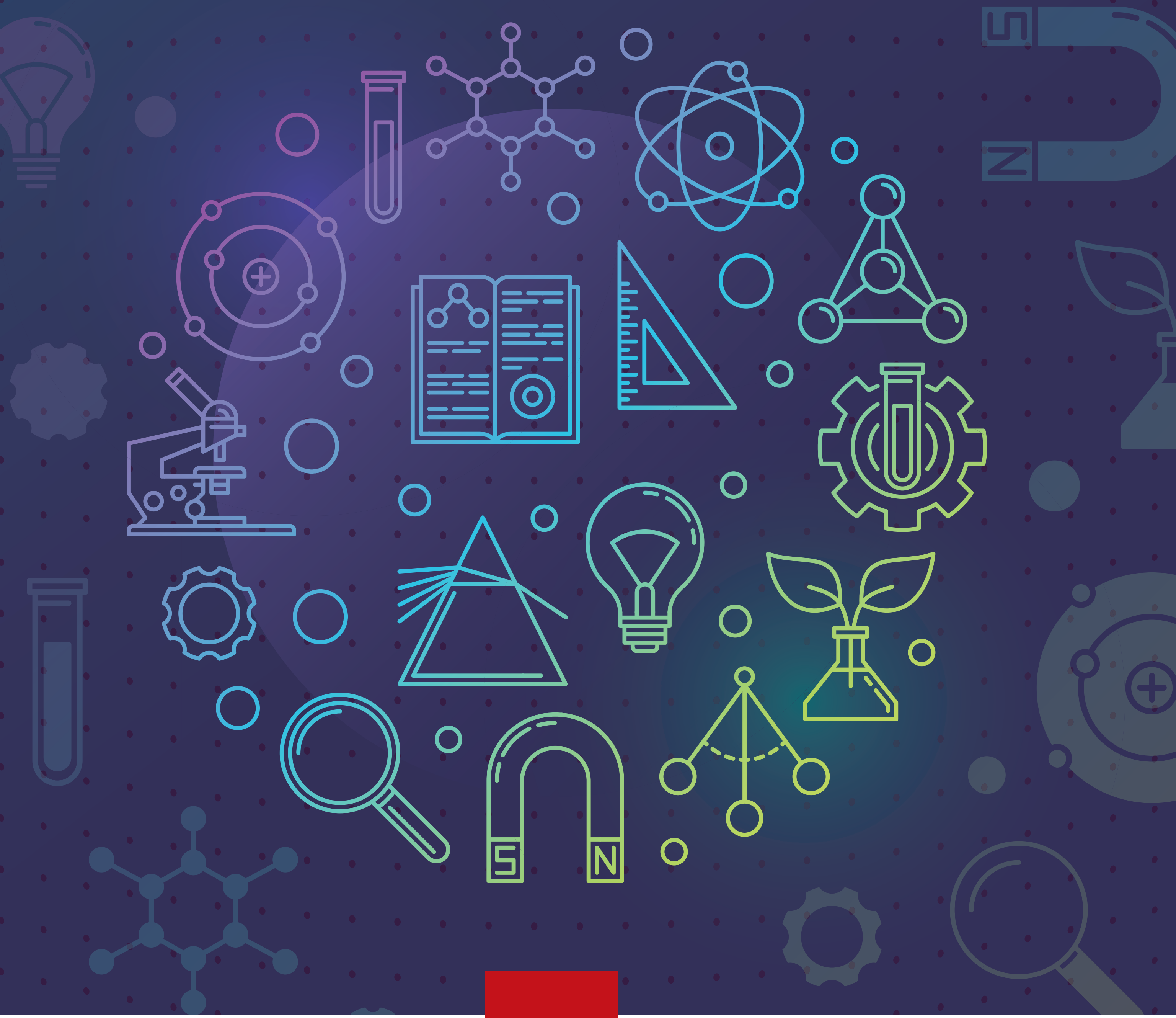
INDISPENSABLE

SCIENCE AND TECHNOLOGY



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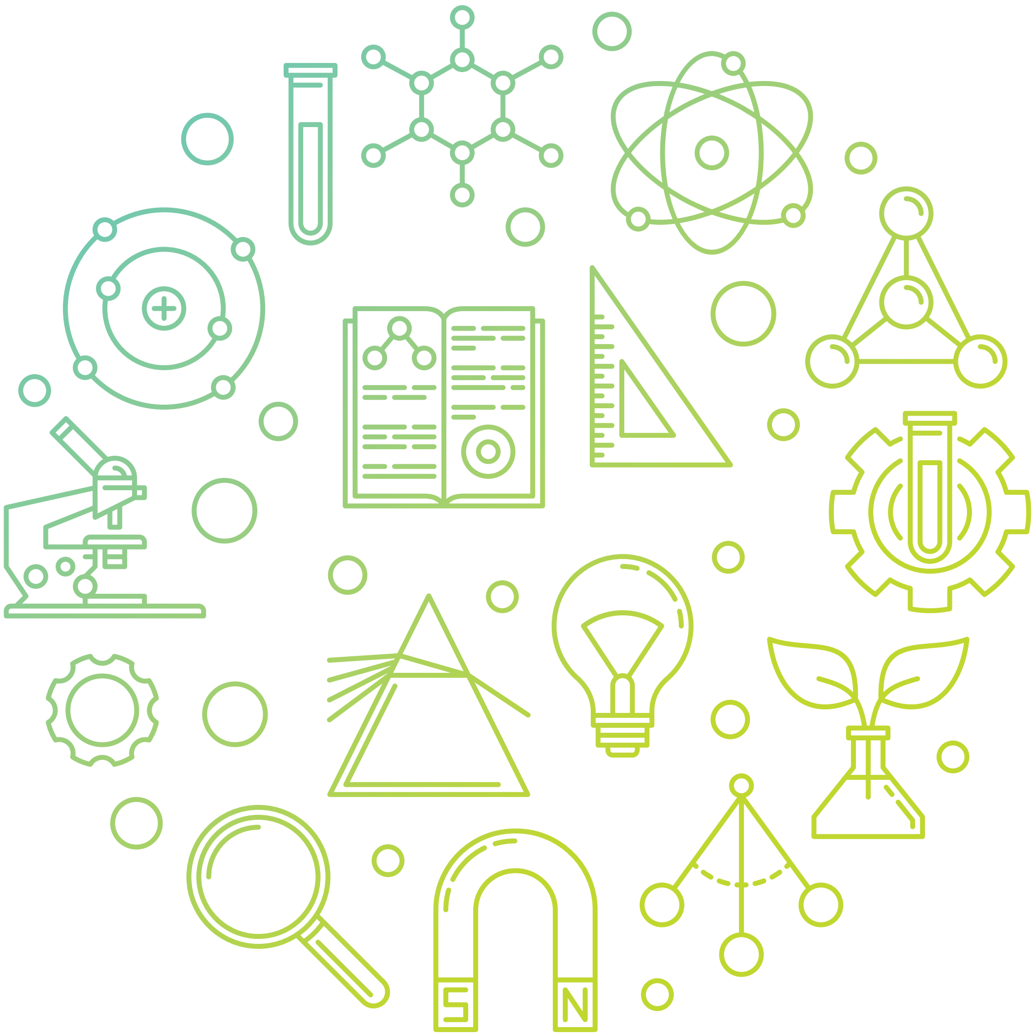

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INDISPENSABLE Science and Technology

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FOREWORD

INDISPENSABLE Science and Technology is a useful tool for anyone wanting to solve a scientific or technological problem, calculate, represent or model a scientific or technological process, gather data and represent it appropriately, establish relations, apply strategies, use scientific reasoning, communicate using appropriate terminology or carry out any other task linked to science and technology.

The first part is subdivided into two sections: mathematical and scientific prerequisites. In mathematics, the mathematical reference groups together parameters for isolating a variable and methods for calculating area, volume and the slope of a line. The scientific prerequisites section presents useful knowledge for correct use of constants, units of measure, significant digits and rounded numbers, scientific notation and the principle of uncertainty. For some, this part will serve as a review of previously acquired knowledge, while for others it will be a reference source for the acquisition of new knowledge or to allow a scientific or technological task to be performed.

The second part covers the worlds of knowledge in detail, in a concrete, useful and relevant manner with the aim of inductively and deductively supporting the learning process, giving meaning to the knowledge and skills to be developed. The knowledge, methods and procedures are presented clearly to facilitate understanding and their use across different scientific and technological contexts. The various strategies and procedures are supported by many examples, illustrations, tables etc. to facilitate comprehension and use.

Thus, users will find all the knowledge that will help them perform quality work, show efficiency and accuracy, and demonstrate scientific rigour: competencies that are essential in learning and evaluation contexts.

The third part presents concepts linked to safety: the WHMIS/GHS, laboratory and workshop safety rules and safety instructions when working with electricity. Detailed workshop and laboratory techniques are also presented in a simple and concise way in order to facilitate their use.

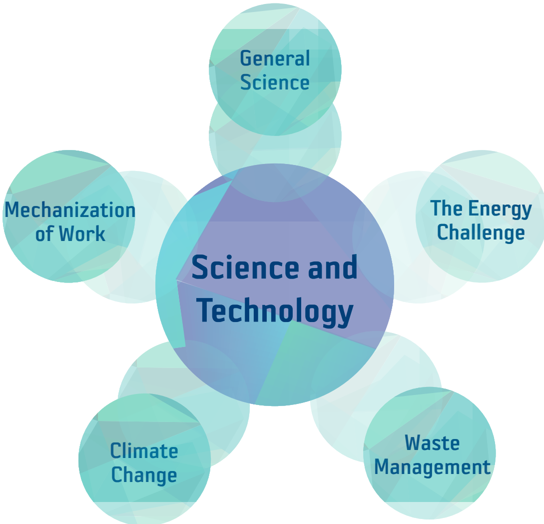
The fourth part, which focuses on technological communication, explains the principal elements of communication: the steps and use of appropriate techniques according the context of the work to be carried out. This part also presents good usage practices for digital tools with the help of clear and precise explanations.

In the fifth part, covering scientific methods and strategies, the user will discover analysis and exploration strategies, and will learn about scientific methods used to validate a hypothesis.

Finally, the last part allows a deeper understanding of scientific and technological culture and media by situating the parameters of the evolution of mathematics over time and from the perspective of personalities and concepts, while offering access to useful references.

INTRODUCTION

Science and technology play an ever-growing role in our lives and contribute significantly to the transformation of society. They are ubiquitous in daily life, in a multitude of objects we use and in the different areas of human activity.



INDISPENSABLE Science and Technology is a treasure trove of general scientific knowledge and more specific knowledge pertaining to the energy challenge, climate change, mechanization of work and waste management. Its simple and accessible format is designed to assist users in their learning. A veritable compilation of Secondary IV scientific and technological knowledge, this resource is a unique companion tool that clearly explains strategies, methods, procedures, rules and techniques.

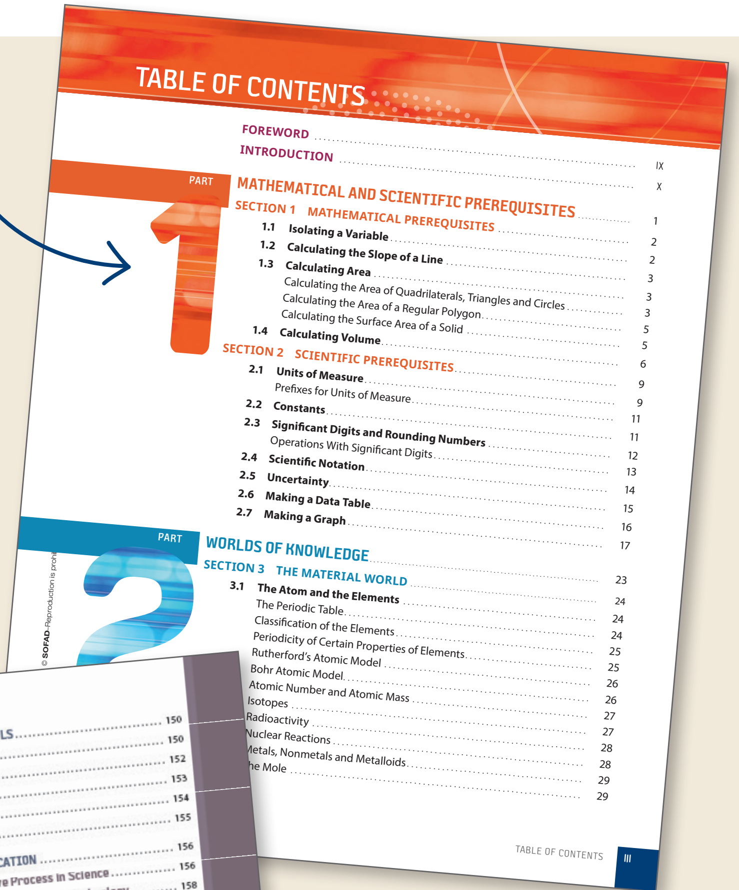
This guide also deals with various important aspects of learners' success in science and technology, such as preparing for examinations, communication and use of digital tools. It offers the opportunity to delve deeper into scientific processes and methods, with a focus on the application of knowledge and, more importantly, on how and when to put this knowledge to use.

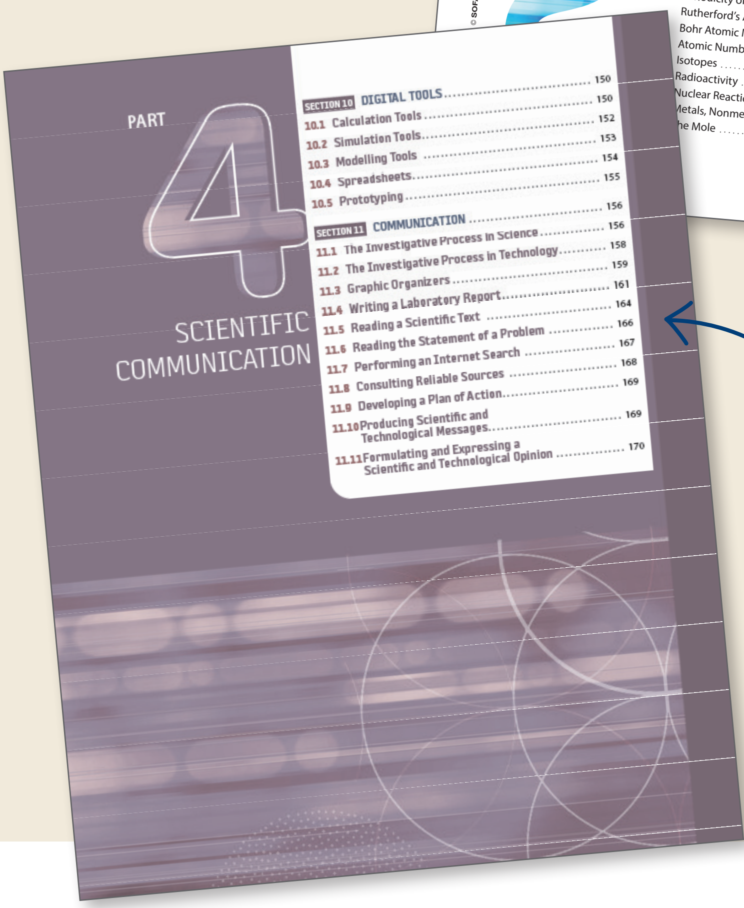
The illustrations, diagrams and explanations contained herein are organized so as to help you find what you are looking for easily and quickly. The content is presented as concisely as possible to support learning in different contexts.

We hope that this resource will provide you with valuable assistance as you learn and prepare for evaluation.

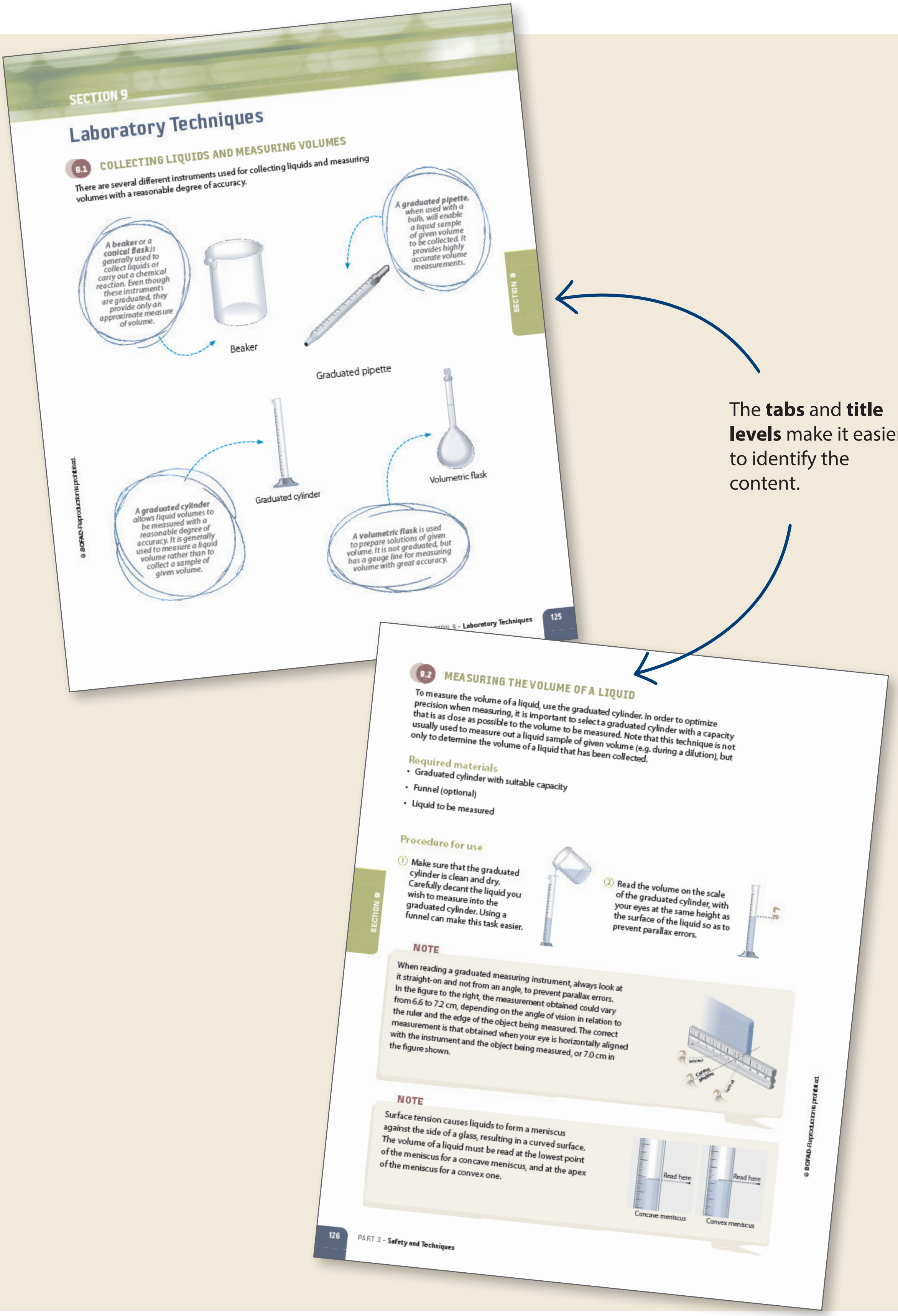
An overview of INDISPENSABLE SCIENCE AND TECHNOLOGY

The **table of contents** is clear and detailed.





The title and a summary view of the contents appear at the beginning of each of the **four parts**.



SECTION 9

Laboratory Techniques

9.1 COLLECTING LIQUIDS AND MEASURING VOLUMES

There are several different instruments used for collecting liquids and measuring volumes with a reasonable degree of accuracy.

A **beaker** or a **conical flask** is generally used to collect liquids or carry out a chemical reaction. Even though these instruments are graduated, they provide only an approximate measure of volume.

Beaker

A **graduated pipette**, when used with a bulb, will enable a liquid sample of given volume to be collected. It provides highly accurate volume measurements.

Graduated pipette

A **graduated cylinder** allows liquid volumes to be measured with a reasonable degree of accuracy. It is generally used to measure a liquid volume rather than to collect a sample of given volume.

Graduated cylinder

A **volumetric flask** is used to prepare solutions of given volume. It is not graduated, but has a gauge line for measuring volume with great accuracy.

Volumetric flask

9.2 MEASURING THE VOLUME OF A LIQUID

To measure the volume of a liquid, use the graduated cylinder. In order to optimize precision when measuring, it is important to select a graduated cylinder with a capacity that is as close as possible to the volume to be measured. Note that this technique is not usually used to measure out a liquid sample of given volume (e.g. during a dilution), but only to determine the volume of a liquid that has been collected.

Required materials

- Graduated cylinder with suitable capacity
- Funnel (optional)
- Liquid to be measured

Procedure for use

1. Make sure that the graduated cylinder is clean and dry. Carefully decant the liquid you wish to measure into the graduated cylinder. Using a funnel can make this task easier.
2. Read the volume on the scale of the graduated cylinder, with your eyes at the same height as the surface of the liquid so as to prevent parallax errors.

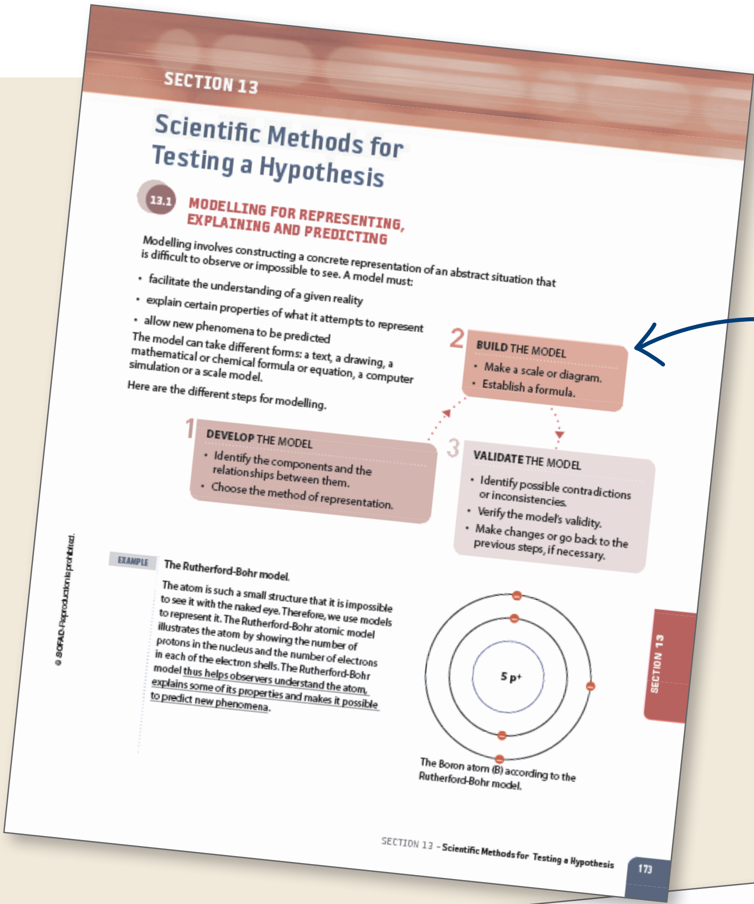
NOTE

When reading a graduated measuring instrument, always look at it straight-on and not from an angle, to prevent parallax errors. In the figure to the right, the measurement obtained could vary from 6.6 to 7.2 cm, depending on the angle of vision in relation to the ruler and the edge of the object being measured. The correct measurement is that obtained when your eye is horizontally aligned with the instrument and the object being measured, or 7.0 cm in the figure shown.

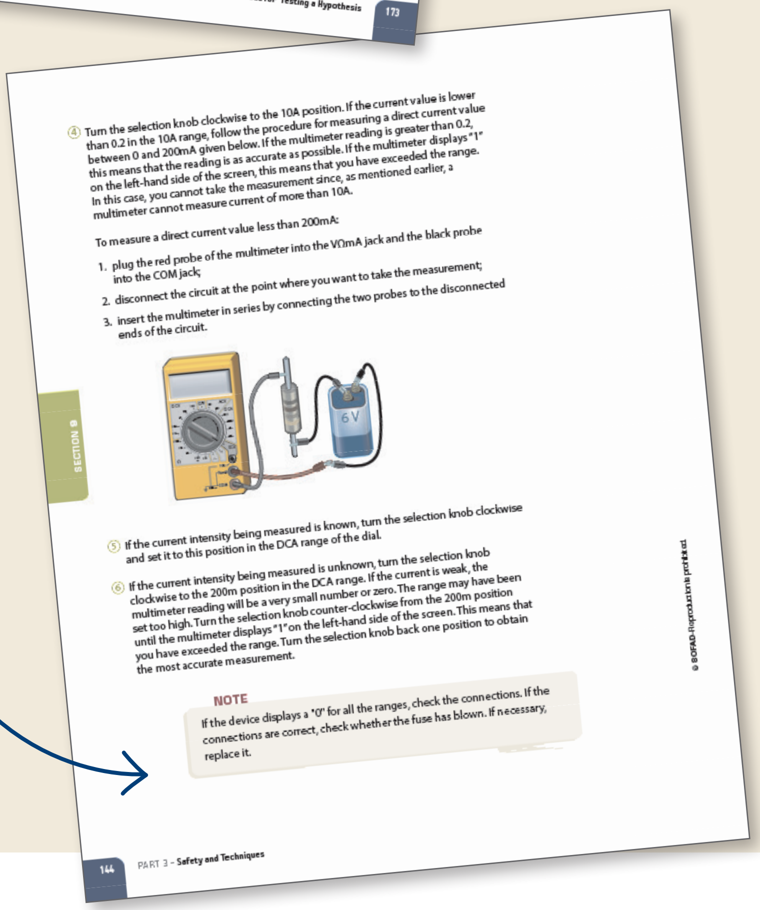
NOTE

Surface tension causes liquids to form a meniscus against the side of a glass, resulting in a curved surface. The volume of a liquid must be read at the lowest point of the meniscus for a concave meniscus, and at the apex of the meniscus for a convex one.

The **tabs** and **title levels** make it easier to identify the content.

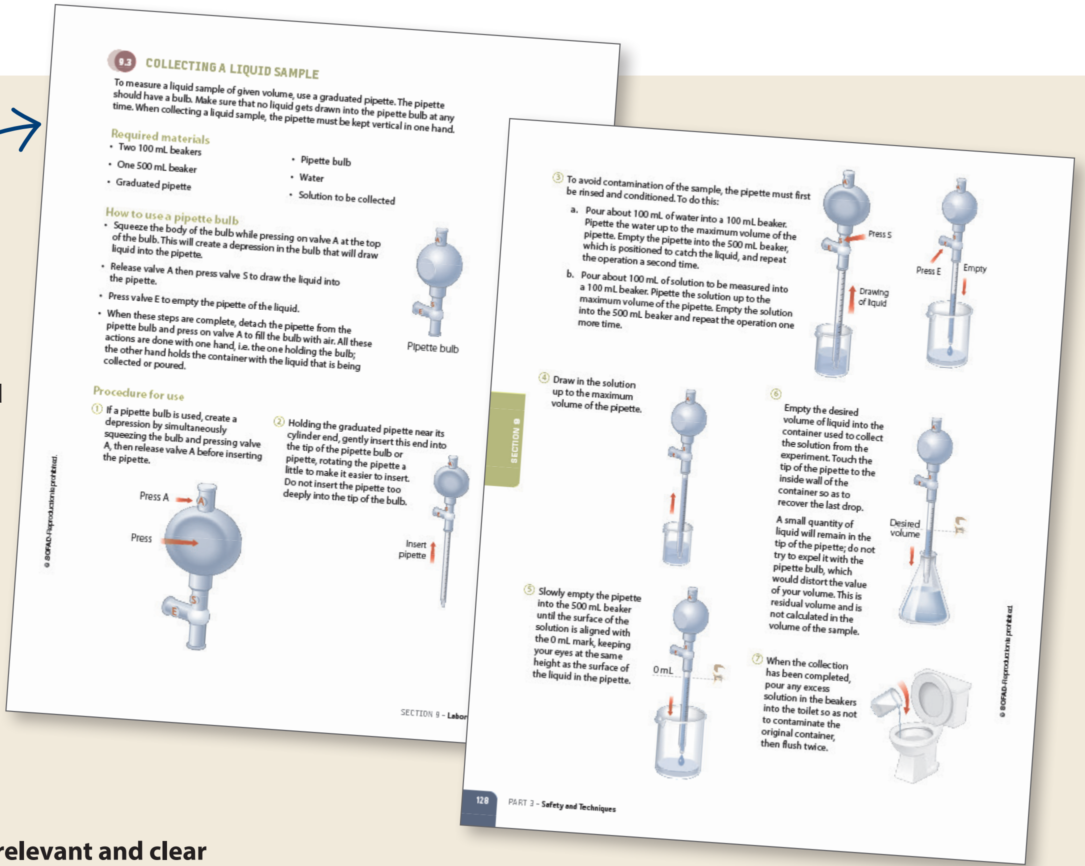


Scientific strategies and **methods** are presented in a simple manner to facilitate their use.



The **Note** section provides additional information or explanations of certain concepts.

Techniques and **safety rules** are presented in a succinct and visually organized way to make them easier to understand and use.


9.3 COLLECTING A LIQUID SAMPLE

To measure a liquid sample of given volume, use a graduated pipette. The pipette should have a bulb. Make sure that no liquid gets drawn into the pipette bulb at any time. When collecting a liquid sample, the pipette must be kept vertical in one hand.

Required materials

- Two 100 mL beakers
- One 500 mL beaker
- Graduated pipette
- Pipette bulb
- Water
- Solution to be collected

How to use a pipette bulb

- Squeeze the body of the bulb while pressing on valve A at the top of the bulb. This will create a depression in the bulb that will draw liquid into the pipette.
- Release valve A then press valve S to draw the liquid into the pipette.
- Press valve E to empty the pipette of the liquid.
- When these steps are complete, detach the pipette from the pipette bulb and press on valve A to fill the bulb with air. All these actions are done with one hand, i.e. the one holding the bulb; the other hand holds the container with the liquid that is being collected or poured.

Procedure for use

① If a pipette bulb is used, create a depression by simultaneously squeezing the bulb and pressing valve A, then release valve A before inserting the pipette.

② Holding the graduated pipette near its cylinder end, gently insert this end into the tip of the pipette bulb or pipette, rotating the pipette a little to make it easier to insert. Do not insert the pipette too deeply into the tip of the bulb.

③ To avoid contamination of the sample, the pipette must first be rinsed and conditioned. To do this:

a. Pour about 100 mL of water into a 100 mL beaker. Pipette the water up to the maximum volume of the pipette. Empty the pipette into the 500 mL beaker, which is positioned to catch the liquid, and repeat the operation a second time.

b. Pour about 100 mL of solution to be measured into a 100 mL beaker. Pipette the solution up to the maximum volume of the pipette. Empty the solution into the 500 mL beaker and repeat the operation one more time.

④ Draw in the solution up to the maximum volume of the pipette.

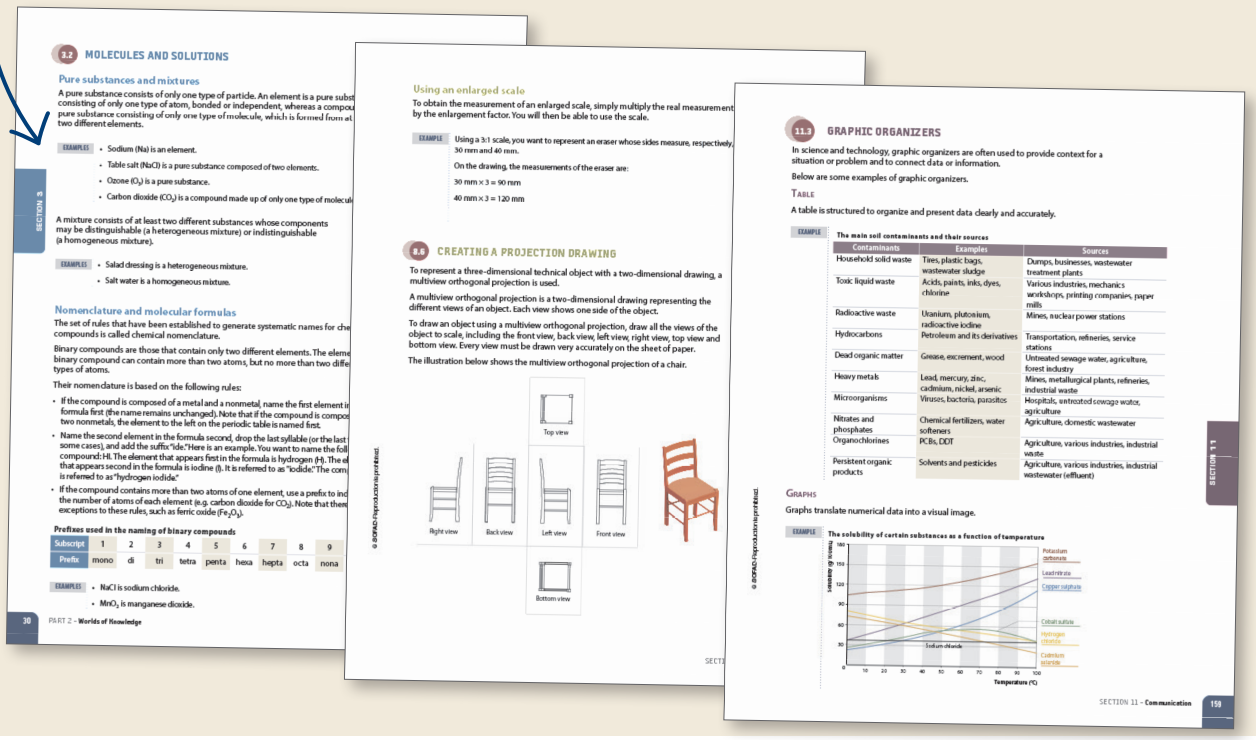
⑤ Slowly empty the pipette into the 500 mL beaker until the surface of the solution is aligned with the 0 mL mark, keeping your eyes at the same height as the surface of the liquid in the pipette.

⑥ Empty the desired volume of liquid into the container used to collect the solution from the experiment. Touch the tip of the pipette to the inside wall of the container so as to recover the last drop.

A small quantity of liquid will remain in the tip of the pipette; do not try to expel it with the pipette bulb, which would distort the value of your volume. This is residual volume and is not calculated in the volume of the sample.

⑦ When the collection has been completed, pour any excess solution in the beakers into the toilet so as not to contaminate the original container, then flush twice.

Numerous relevant and clear examples support the explanations and make them easier to understand.


3.2 MOLECULES AND SOLUTIONS

Pure substances and mixtures

A pure substance consists of only one type of particle. An element is a pure subst[ance] consisting of only one type of atom, bonded or independent, whereas a compou[nd is a] pure substance consisting of only one type of molecule, which is formed from at [least] two different elements.

EXAMPLES
- Sodium (Na) is an element.
- Table salt (NaCl) is a pure substance composed of two elements.
- Ozone (O_3) is a pure substance.
- Carbon dioxide (CO_2) is a compound made up of only one type of molecul[e]

A mixture consists of at least two different substances whose components may be distinguishable (a heterogeneous mixture) or indistinguishable (a homogeneous mixture).

EXAMPLES
- Salad dressing is a heterogeneous mixture.
- Salt water is a homogeneous mixture.

Nomenclature and molecular formulas

The set of rules that have been established to generate systematic names for che[mical] compounds is called chemical nomenclature.

Binary compounds are those that contain only two different elements. The eleme[nts of a] binary compound can contain more than two atoms, but no more than two diffe[rent] types of atoms.

Their nomenclature is based on the following rules:

- If the compound is composed of a metal and a nonmetal, name the first element i[n the] formula first (the name remains unchanged). Note that if the compound is compos[ed of] two nonmetals, the element to the left on the periodic table is named first.
- Name the second element in the formula second, drop the last syllable (or the last some cases), and add the suffix "ide." Here is an example. You want to name the foll[owing] compound: HI. The element that appears first in the formula is hydrogen (H). The el[ement] that appears second in the formula is iodine (I). It is referred to as "iodide." The com[pound] is referred to as "hydrogen iodide."
- If the compound contains more than two atoms of one element, use a prefix to ind[icate] the number of atoms of each element (e.g. carbon dioxide for CO_2). Note that there [are] exceptions to these rules, such as ferric oxide (Fe_2O_3).

Prefixes used in the naming of binary compounds

Subscript	1	2	3	4	5	6	7	8	9
Prefix	mono	di	tri	tetra	penta	hexa	hepta	octa	nona

EXAMPLES
- NaCl is sodium chloride.
- MnO_2 is manganese dioxide.

Using an enlarged scale

To obtain the measurement of an enlarged scale, simply multiply the real measurement by the enlargement factor. You will then be able to use the scale.

EXAMPLE Using a 3:1 scale, you want to represent an eraser whose sides measure, respectively, 30 mm and 40 mm.

On the drawing, the measurements of the eraser are:

30 mm × 3 = 90 mm

40 mm × 3 = 120 mm

8.6 CREATING A PROJECTION DRAWING

To represent a three-dimensional technical object with a two-dimensional drawing, a multiview orthogonal projection is used.

A multiview orthogonal projection is a two-dimensional drawing representing the different views of an object. Each view shows one side of the object.

To draw an object using a multiview orthogonal projection, draw all the views of the object to scale, including the front view, back view, left view, right view, top view and bottom view. Every view must be drawn very accurately on the sheet of paper.

The illustration below shows the multiview orthogonal projection of a chair.

11.3 GRAPHIC ORGANIZERS

In science and technology, graphic organizers are often used to provide context for a situation or problem and to connect data or information.

Below are some examples of graphic organizers.

TABLE

A table is structured to organize and present data clearly and accurately.

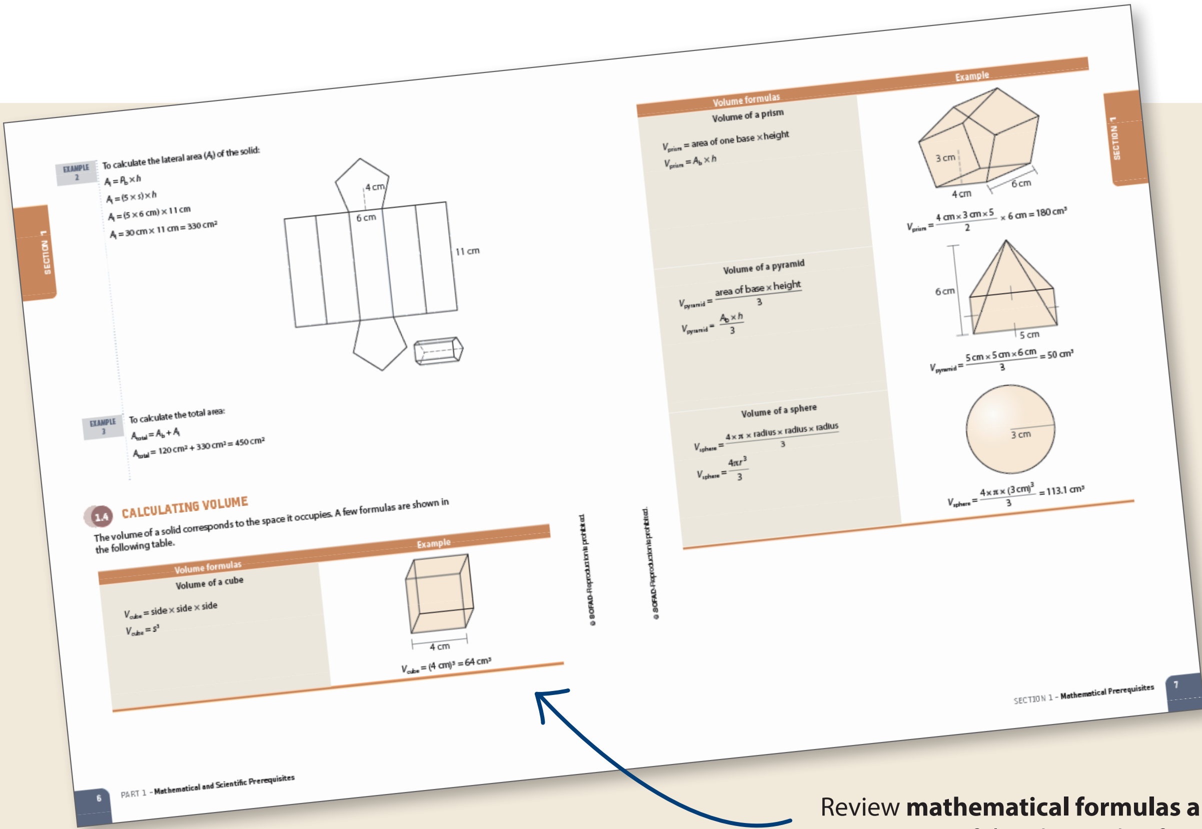
EXAMPLE The main soil contaminants and their sources

Contaminants	Examples	Sources
Household solid waste	Tires, plastic bags, wastewater sludge	Dumps, businesses, wastewater treatment plants
Toxic liquid waste	Acids, paints, inks, dyes, chlorine	Various industries, mechanics workshops, printing companies, paper mills
Radioactive waste	Uranium, plutonium, radioactive iodine	Mines, nuclear power stations
Hydrocarbons	Petroleum and its derivatives	Transportation, refineries, service stations
Dead organic matter	Grease, excrement, wood	Untreated sewage water, agriculture, forest industry
Heavy metals	Lead, mercury, zinc, cadmium, nickel, arsenic	Mines, metallurgical plants, refineries, industrial waste
Microorganisms	Viruses, bacteria, parasites	Hospitals, untreated sewage water, agriculture
Nitrates and phosphates	Chemical fertilizers, water softeners	Agriculture, domestic wastewater
Organochlorines	PCBs, DDT	Agriculture, various industries, industrial waste
Persistent organic products	Solvents and pesticides	Agriculture, various industries, industrial wastewater (effluent)

GRAPHS

Graphs translate numerical data into a visual image.

EXAMPLE The solubility of certain substances as a function of temperature


SECTION 1

EXAMPLE 2 To calculate the lateral area (A_l) of the solid:

$A_l = P_b \times h$

$A_l = (5 \times s) \times h$

$A_l = (5 \times 6\ cm) \times 11\ cm$

$A_l = 30\ cm \times 11\ cm = 330\ cm^2$

EXAMPLE 3 To calculate the total area:

$A_{total} = A_b + A_l$

$A_{total} = 120\ cm^2 + 330\ cm^2 = 450\ cm^2$

1.4 CALCULATING VOLUME

The volume of a solid corresponds to the space it occupies. A few formulas are shown in the following table.

Volume formulas	Example
Volume of a cube $V_{cube} = side \times side \times side$ $V_{cube} = s^3$	$V_{cube} = (4\ cm)^3 = 64\ cm^3$

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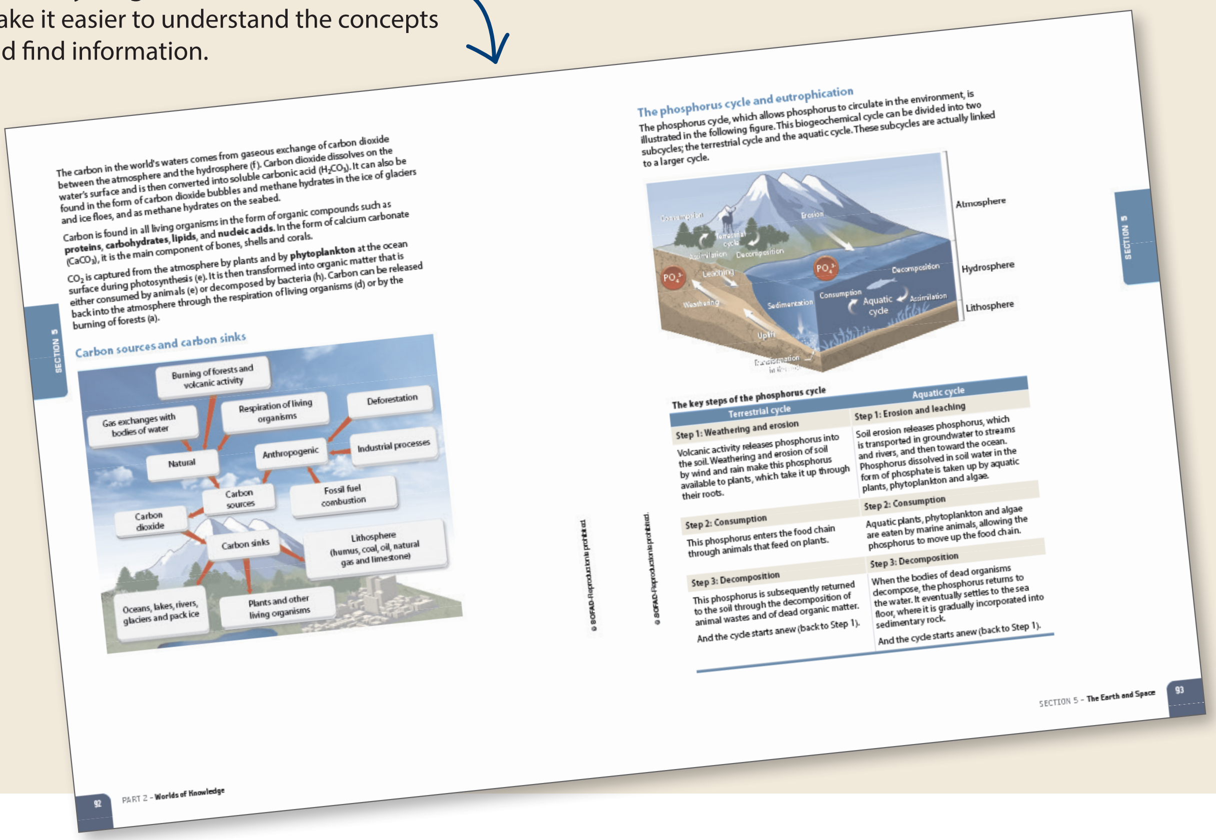
PART 1 – Mathematical and Scientific Prerequisites 6

Volume formulas	Example
Volume of a prism V_{prism} = area of one base × height $V_{prism} = A_b \times h$	$V_{prism} = \frac{4\ cm \times 3\ cm \times 5}{2} \times 6\ cm = 180\ cm^3$
Volume of a pyramid $V_{pyramid} = \frac{\text{area of base} \times \text{height}}{3}$ $V_{pyramid} = \frac{A_b \times h}{3}$	$V_{pyramid} = \frac{5\ cm \times 5\ cm \times 6\ cm}{3} = 50\ cm^3$
Volume of a sphere $V_{sphere} = \frac{4 \times \pi \times radius \times radius \times radius}{3}$ $V_{sphere} = \frac{4\pi r^3}{3}$	$V_{sphere} = \frac{4 \times \pi \times (3\ cm)^3}{3} = 113.1\ cm^3$

SECTION 1 – Mathematical Prerequisites 7

Review **mathematical formulas and concepts** useful in the study of science and technology.

The **many diagrams and illustrations** make it easier to understand the concepts and find information.


The carbon in the world's waters comes from gaseous exchange of carbon dioxide between the atmosphere and the hydrosphere (f). Carbon dioxide dissolves on the water's surface and is then converted into soluble carbonic acid (H_2CO_3). It can also be found in the form of carbon dioxide bubbles and methane hydrates in the ice of glaciers and ice floes, and as methane hydrates on the seabed.

Carbon is found in all living organisms in the form of organic compounds such as **proteins**, **carbohydrates**, **lipids**, and **nucleic acids**. In the form of calcium carbonate ($CaCO_3$), it is the main component of bones, shells and corals.

CO_2 is captured from the atmosphere by plants and by **phytoplankton** at the ocean surface during photosynthesis (e). It is then transformed into organic matter that is either consumed by animals (e) or decomposed by bacteria (h). Carbon can be released back into the atmosphere through the respiration of living organisms (d) or by the burning of forests (a).

Carbon sources and carbon sinks

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The phosphorus cycle and eutrophication

The phosphorus cycle, which allows phosphorus to circulate in the environment, is illustrated in the following figure. This biogeochemical cycle can be divided into two subcycles; the terrestrial cycle and the aquatic cycle. These subcycles are actually linked to a larger cycle.

The key steps of the phosphorus cycle

Terrestrial cycle	Aquatic cycle
Step 1: Weathering and erosion Volcanic activity releases phosphorus into the soil. Weathering and erosion of soil by wind and rain make this phosphorus available to plants, which take it up through their roots.	**Step 1: Erosion and leaching** Soil erosion releases phosphorus, which is transported in groundwater to streams and rivers, and then toward the ocean. Phosphorus dissolved in soil water in the form of phosphate is taken up by aquatic plants, phytoplankton and algae.
Step 2: Consumption This phosphorus enters the food chain through animals that feed on plants.	**Step 2: Consumption** Aquatic plants, phytoplankton and algae are eaten by marine animals, allowing the phosphorus to move up the food chain.
Step 3: Decomposition This phosphorus is subsequently returned to the soil through the decomposition of animal wastes and of dead organic matter. And the cycle starts anew (back to Step 1).	**Step 3: Decomposition** When the bodies of dead organisms decompose, the phosphorus returns to the water. It eventually settles to the sea floor, where it is gradually incorporated into sedimentary rock. And the cycle starts anew (back to Step 1).

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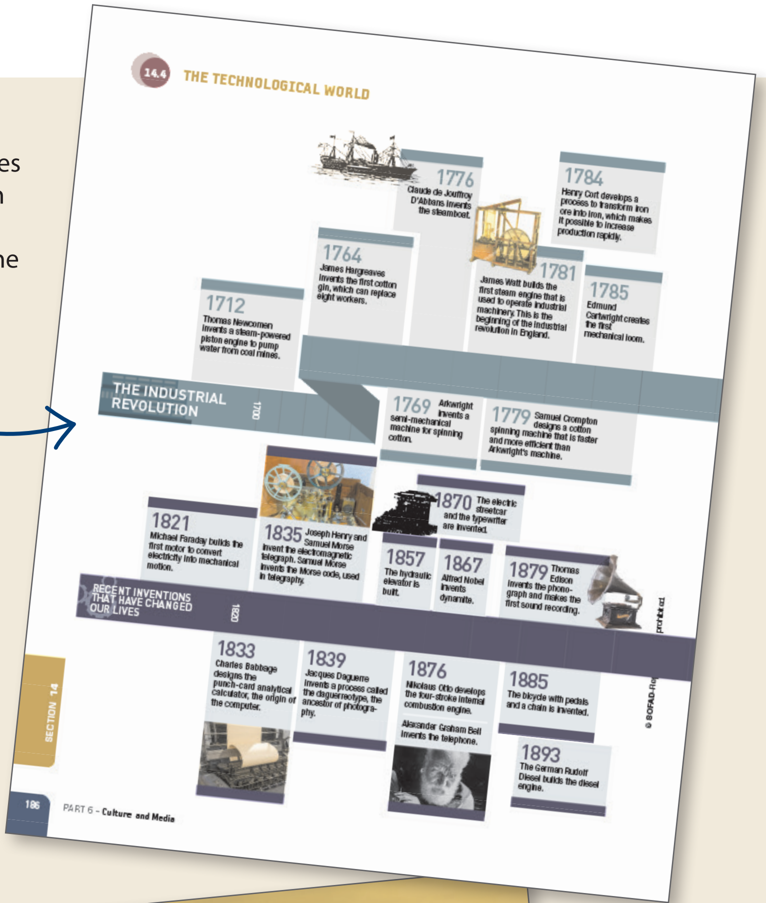
SECTION 5 – The Earth and Space 93

Schematic timelines show the evolution of science and technology from the perspective of key figures and concepts.



14.4 THE TECHNOLOGICAL WORLD

THE INDUSTRIAL REVOLUTION

1712 Thomas Newcomen invents a steam-powered piston engine to pump water from coal mines.

1764 James Hargreaves invents the first cotton gin, which can replace eight workers.

1769 Arkwright invents a semi-mechanical machine for spinning cotton.

1776 Claude de Jouffroy D'Abbans invents the steamboat.

1779 Samuel Crompton designs a cotton spinning machine that is faster and more efficient than Arkwright's machine.

1781 James Watt builds the first steam engine that is used to operate industrial machinery. This is the beginning of the industrial revolution in England.

1784 Henry Cort develops a process to transform iron ore into iron, which makes it possible to increase production rapidly.

1785 Edmund Cartwright creates the first mechanical loom.

RECENT INVENTIONS THAT HAVE CHANGED OUR LIVES

1821 Michael Faraday builds the first motor to convert electricity into mechanical motion.

1833 Charles Babbage designs the punch-card analytical calculator, the origin of the computer.

1835 Joseph Henry and Samuel Morse invent the electromagnetic telegraph. Samuel Morse invents the Morse code, used in telegraphy.

1839 Jacques Daguerre invents a process called the daguerreotype, the ancestor of photography.

1857 The hydraulic elevator is built.

1867 Alfred Nobel invents dynamite.

1870 The electric streetcar and the typewriter are invented.

1876 Nikolaus Otto develops the four-stroke internal combustion engine. Alexander Graham Bell invents the telephone.

1879 Thomas Edison invents the phonograph and makes the first sound recording.

1885 The bicycle with pedals and a chain is invented.

1893 The German Rudolf Diesel builds the diesel engine.

SECTION 14

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SECTION 15

Essential Vocabulary in Science and Technology

Abiotic factors
Environmental conditions that affect populations.

Absolute value
Mathematical operation on a number that results in its positive value. For example, the absolute value of −2 is written as |−2| and the result is 2.

Abundance
Refers to the relative proportion in nature of an isotope compared to other isotopes of the same element. It is expressed as a percentage.

Accumulator
A rechargeable cell or battery.

Acid deposition
Term encompassing different forms of precipitation (fog, snow, hail, dew, rain and sleet) and dry substances (dust, sand, etc.) that have greater than normal acidity levels (pH < 5).

Acid
An electrolyte that releases hydrogen ions (H^+) in aqueous solution. Its pH is less than 7.

Acid-base neutralization
Chemical transformation that occurs when an acid and a base are mixed together. The products are water and a salt.

Activation
Process by which air is injected into wastewater to promote the decomposition of organic matter by microorganisms.

Actual current
Direction is based on the flow of electrons from the negative terminal to the positive terminal.

Adhesion
Phenomenon by which the surfaces of a part or a technical object tend to remain in contact with each other. Adhesion prevents slipping.

Aerobic
Refers to an environment that contains oxygen or to a living organism that requires oxygen to function.

Aerosols
Fine solid particles or liquid droplets suspended in air.

Air mass
Homogeneous assembly of air molecules having similar characteristics, such as temperature, humidity and pressure.

Albedo
Reflectiveness of a surface. The whiter the surface (e.g. snow cover), the greater its reflectivity and the higher the albedo.

Alkali metal
Soft, very reactive metal in group 1 (IA) of the periodic table (lithium family).

Alkaline earth metal
Metal belonging to group 2 (IIA) of the periodic table (beryllium family).

SECTION 15

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The main terms used in science and technology that appear in the guide are defined in the **glossary**, found at the end of the guide.

A UNIQUE REFERENCE TOOL THAT SUPPORTS SCIENCE AND TECHNOLOGY LEARNING

THE IDEAL COMPLEMENT TO ANY SCIENCE AND TECHNOLOGY COLLECTION

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SCIENCE AND TECHNOLOGY

A comprehensive resource designed to promote understanding of scientific and technological knowledge and techniques at the Secondary IV level.

A must-have resource for updating your knowledge or finding essential information to advance your learning.

PART I
MATHEMATICAL AND SCIENTIFIC PREREQUISITES

- Isolating a variable
- Calculating slope, areas and volumes
- Units of measure, constants
- Significant digits and rounding numbers
- Scientific notation
- Uncertainty

PART II
WORLDS OF KNOWLEDGE

- The Material World
- The Technological World
- The Earth and Space
- The Living World

PART III
SAFETY AND TECHNIQUES

- Workshop and laboratory safety symbols and rules; electrical safety instructions
- Workshop techniques
- Laboratory techniques

PART IV
SCIENTIFIC COMMUNICATION

- Digital tools: calculations, simulations, modelling, spreadsheets, databases, prototyping, etc.
- Communication: investigative approach, graphic organizers, writing a report, reading a scientific text, searching for credible sources, etc.

PART V
STRATEGIES AND SCIENTIFIC METHODS

- Exploration and analytical strategies
- Scientific methods for testing a hypothesis: modelling, observation, experimentation, documentary research, prototype design

PART VI
CULTURE AND MEDIA

- Cultural references: timelines showing significant scientific breakthroughs and technological inventions by world of knowledge (Material, Technological, Earth and Space, Living)
- Basic vocabulary in science and technology
- Mediagraphy: useful online references

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