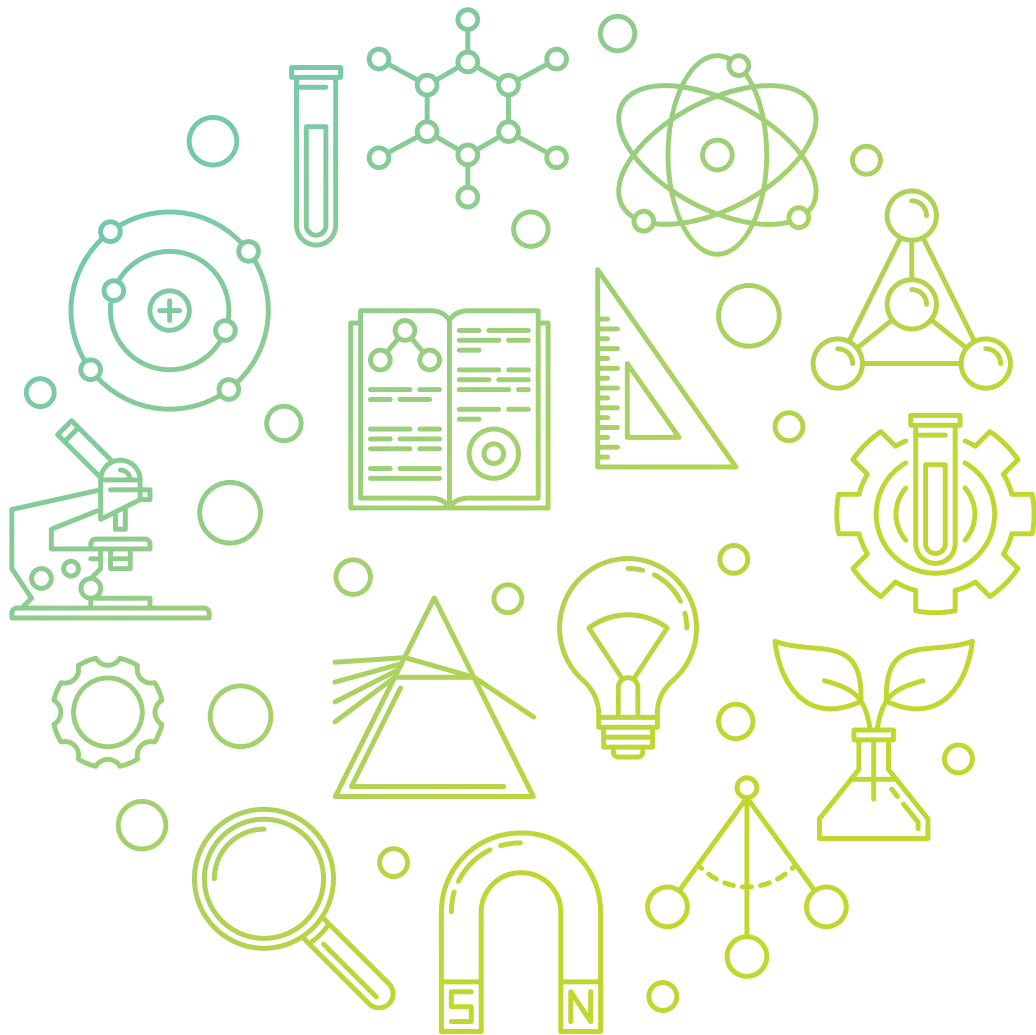


INDISPENSABLE SCIENCE AND TECHNOLOGY



INDISPENSABLE SCIENCE AND TECHNOLOGY



SOFAD

INDISPENSABLE Science and Technology

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TABLE OF CONTENTS

FOREWORD	IX
-----------------------	----

INTRODUCTION	X
---------------------------	---

PART



MATHEMATICAL AND SCIENTIFIC PREREQUISITES	1
--	---

SECTION 1 MATHEMATICAL PREREQUISITES	2
---	---

1.1 Isolating a Variable	2
---------------------------------------	---

1.2 Calculating the Slope of a Line	3
--	---

1.3 Calculating Area	3
-----------------------------------	---

Calculating the Area of Quadrilaterals, Triangles and Circles	3
---	---

Calculating the Area of a Regular Polygon	5
---	---

Calculating the Surface Area of a Solid	5
---	---

1.4 Calculating Volume	6
-------------------------------------	---

SECTION 2 SCIENTIFIC PREREQUISITES	9
---	---

2.1 Units of Measure	9
-----------------------------------	---

Prefixes for Units of Measure	11
-------------------------------------	----

2.2 Constants	11
----------------------------	----

2.3 Significant Digits and Rounding Numbers	12
--	----

Operations With Significant Digits	13
--	----

2.4 Scientific Notation	14
--------------------------------------	----

2.5 Uncertainty	15
------------------------------	----

2.6 Making a Data Table	16
--------------------------------------	----

2.7 Making a Graph	17
---------------------------------	----

PART



WORLDS OF KNOWLEDGE	23
----------------------------------	----

SECTION 3 THE MATERIAL WORLD	24
---	----

3.1 The Atom and the Elements	24
--	----

The Periodic Table	24
--------------------------	----

Classification of the Elements	25
--------------------------------------	----

Periodicity of Certain Properties of Elements	25
---	----

Rutherford's Atomic Model	26
---------------------------------	----

Bohr Atomic Model	26
-------------------------	----

Atomic Number and Atomic Mass	27
-------------------------------------	----

Isotopes	27
----------------	----

Radioactivity	28
---------------------	----

Nuclear Reactions	28
-------------------------	----

Metals, Nonmetals and Metalloids	29
--	----

The Mole	29
----------------	----

3.2 Molecules and Solutions	30
Pure Substances and Mixtures	30
Nomenclature and Molecular Formulas	30
Lewis Notation	32
Chemical Bonds	32
Solubility	33
Precipitation	33
Solution Concentration	34
Molar Concentration	36
Dissolution	36
Dilution	37
Electrolytes	38
Ionic and Molecular Solids	38
Ions and Electrolytes	39
Acids, Bases and Salts	39
pH	41
3.3 Forms of Energy	42
The Principal Forms of Energy	42
Other Forms of Energy	43
Law of Conservation of Energy	44
Energy Efficiency	44
3.4 Transformations of Matter	45
The Law of Conservation of Mass	45
Balancing Chemical Reaction Equations	45
Acid-Base Neutralization	46
Salt	47
Oxidation	47
Decomposition and Synthesis	47
Stoichiometry	48
Chemical Changes in the Biogeochemical Carbon Cycle	48
Oxidation Reactions	48
3.5 Electricity and Magnetism	49
Power	49
The Kilowatt Hour	50
Electrostatics	50
Coulomb's Law	52
Electric Field	53
Conductors and Insulators	53
Voltage and Resistance	54
Ohm's Law	55
Electrical Power	56
The Joule Effect	56
Kirchhoff's Laws	57

The Equivalent Circuit and Equivalent Resistance	57
Series Circuits.....	58
Parallel Circuits	59
Combination Circuits.....	60
Magnetism	61
Magnetic Properties of Materials	61
Electromagnetism.....	62
3.6 Forces and Fluids	63
Fluids	63
Pascal's Principle	64
Bernoulli's Principle	64
Archimedes' Principle	64
Force.....	65
SECTION 4 THE TECHNOLOGICAL WORLD	66
4.1 The Language of Technical Drawing	66
Dimensioning and Functional Tolerance	66
Axonometric Projection.....	67
Multi-View Orthogonal Projections.....	67
Development of a Three-Dimensional Shape	68
The Schematic Diagram.....	68
The Schematic Construction Diagram	69
4.2 Electrical Engineering	69
Functions Within Electrical Circuits	69
4.3 Mechanical Engineering	70
Types of Movement	70
Types of Force and Their Symbols	71
Effects of Forces and Their Symbols	71
Basic Mechanical Operations	72
Attaching Tools.....	72
The Attaching Operation.....	73
The Characteristics of Attachments.....	74
Guiding Function.....	76
Degrees of Freedom of a Part.....	77
Adhesion	78
Types of Parts and Their Function.....	78
Motion Transmission Mechanisms	79
4.4 Manufacturing Technical Objects	80
Steps in the Manufacture of a Technical Object	80
Drilling Tools	81
Threading and Tapping Tools	82
4.5 Materials	83

SECTION 5 THE EARTH AND SPACE	87
5.1 The Lithosphere and Hydrosphere	87
Soil Horizons	87
Soil Profile	88
Ocean Circulation	88
The Lithosphere	88
The Hydrosphere	89
Types of Rocks and Mineral Resources	89
The Carbon Cycle	91
Carbon Sources and Carbon Sinks	92
The Phosphorus Cycle and Eutrophication	93
The Nitrogen Cycle	94
Ocean Acidification	95
Terrestrial Biomes	95
Aquatic Biomes	96
5.2 The Atmosphere and Space	98
Anticyclones and Depressions	98
Convective Cells	98
Smog and the Greenhouse Effect	99
Global Warming	99
Climate Change	99
Acid Rain	100
Mitigation of GHG emissions	100
Adaptation to the Effects of Climate Change	100
SECTION 6 THE LIVING WORLD	101
6.1 Populations and Communities	101
Populations	101
The Life Cycle	102
Community Dynamics	103
Interactions Between Populations in a Community	104
6.2 Ecosystems	104
Ecosystem Dynamics	104
Food Chains	105
Disturbances in the Balance of Ecosystems	105
Climate Change and Ecosystem Biodiversity	106
Ecotoxicology	106
Soil Remediation	107
Wastewater Treatment	108
The Ecological Footprint	108

SAFETY AND TECHNIQUES	109
SECTION 7 SAFETY	110
7.1 The Main WHMIS/GHS Symbols	110
7.2 Laboratory Safety Rules	112
Laser Pointer Safety	114
7.3 Workshop Safety Rules	114
7.4 Electricity Safety Rules	116
SECTION 8 WORKSHOP TECHNIQUES	117
8.1 Drawing Basic Lines in a Technical Drawing	117
8.2 Drawing a Diagram	118
Electrical Circuit Symbols	118
Symbols on Diagrams	119
8.3 Determining the Overall Function of a Technical Object	120
8.4 Creating a Geometric Drawing	121
8.5 Creating a Scale Drawing	122
Using a Reduced Scale	122
Using an Enlarged Scale	123
8.6 Creating a Projection Drawing	123
8.7 Dimensioning a Technical Drawing	124
SECTION 9 LABORATORY TECHNIQUES	125
9.1 Collecting Liquids and Measuring Volumes	125
9.2 Measuring the Volume of a Liquid	126
9.3 Collecting a Liquid Sample	127
9.4 Measuring the Mass of a Solid Using an Electronic Scale	129
9.5 Measuring the Mass of a Solid Using a Triple-Beam Mechanical Balance	130
9.6 Collecting a Solid Sample	131
9.7 Preparing a Solution from a Solid	132
9.8 Diluting a Concentrated Solution	133
9.9 Gravity Filtration	134
9.10 Describing a Solution Based on Its pH	136
9.11 Measuring the pH of a Solution	139
9.12 Measuring the Electrical Conductivity of a Solution	140
9.13 Measuring Electrical Resistance	141
9.14 Measuring Voltage	142
9.15 Measuring Current Intensity	143
9.16 The Optical Microscope and Its Components	145
9.17 Procedure for Operating a Microscope	146
9.18 Preparing a Microscope Slide	147
9.19 Scientific Drawing of an Observation With a Microscope	148

4

SCIENTIFIC COMMUNICATION	149
SECTION 10 DIGITAL TOOLS	150
10.1 Calculation Tools	150
10.2 Simulation Tools	152
10.3 Modelling Tools	153
10.4 Spreadsheets	154
10.5 Prototyping	155
SECTION 11 COMMUNICATION	156
11.1 The Investigative Process in Science	156
11.2 The Investigative Process in Technology	158
11.3 Graphic Organizers	159
11.4 Writing a Laboratory Report	161
11.5 Reading a Scientific Text	164
11.6 Reading the Statement of a Problem	166
11.7 Performing an Internet Search	167
11.8 Consulting Reliable Sources	168
11.9 Developing a Plan of Action	169
11.10 Producing Scientific and Technological Messages	169
11.11 Formulating and Expressing a Scientific and Technological Opinion	170

5

STRATEGIES AND SCIENTIFIC METHODS	171
SECTION 12 STRATEGIES	172
12.1 Exploration Strategies	172
12.2 Analytical Strategies	172
SECTION 13 SCIENTIFIC METHODS FOR TESTING A HYPOTHESIS	173
13.1 Modelling for Representing, Explaining and Predicting	173
13.2 Scientific Observation Method	174
13.3 Experimental Method	174
13.4 Documentary Research	175
13.5 Technological Design Process	176

6

CULTURE AND MEDIA 177

SECTION 14 CULTURAL REFERENCES 178

14.1 The Material World 178

14.2 The Living World 182

14.3 The Earth and Space 184

14.4 The Technological World 186

ESSENTIAL VOCABULARY IN SCIENCE AND TECHNOLOGY 190

MEDIAGRAPHY 216

PHOTO CREDITS 218

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 to 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.

TABLE OF CONTENTS	
FOREWORD	IX
INTRODUCTION	X
PART 1	MATHEMATICAL AND SCIENTIFIC PREREQUISITES
SECTION 1 MATHEMATICAL PREREQUISITES	1
1.1 Isolating a Variable	2
1.2 Calculating the Slope of a Line	2
1.3 Calculating Area	3
Calculating the Area of Quadrilaterals, Triangles and Circles	3
Calculating the Area of a Regular Polygon	3
Calculating the Surface Area of a Solid	5
1.4 Calculating Volume	5
SECTION 2 SCIENTIFIC PREREQUISITES	6
2.1 Units of Measure	9
Prefixes for Units of Measure	9
2.2 Constants	11
2.3 Significant Digits and Rounding Numbers	11
Operations With Significant Digits	12
2.4 Scientific Notation	13
2.5 Uncertainty	14
2.6 Making a Data Table	15
2.7 Making a Graph	16
PART 2	WORLDS OF KNOWLEDGE
SECTION 3 THE MATERIAL WORLD	23
3.1 The Atom and the Elements	24
The Periodic Table	24
Classification of the Elements	24
Periodicity of Certain Properties of Elements	25
Rutherford's Atomic Model	25
Bohr Atomic Model	26
Atomic Number and Atomic Mass	26
Isotopes	27
Radioactivity	27
Nuclear Reactions	28
Metals, Nonmetals and Metalloids	28
The Mole	29

PART 4	SCIENTIFIC COMMUNICATION
SECTION 10 DIGITAL TOOLS	150
10.1 Calculation Tools	150
10.2 Simulation Tools	152
10.3 Modelling Tools	153
10.4 Spreadsheets	154
10.5 Prototyping	155
SECTION 11 COMMUNICATION	156
11.1 The Investigative Process in Science	156
11.2 The Investigative Process in Technology	158
11.3 Graphic Organizers	159
11.4 Writing a Laboratory Report	161
11.5 Reading a Scientific Text	164
11.6 Reading the Statement of a Problem	166
11.7 Performing an Internet Search	167
11.8 Consulting Reliable Sources	168
11.9 Developing a Plan of Action	169
11.10 Producing Scientific and Technological Messages	169
11.11 Formulating and Expressing a Scientific and Technological Opinion	170

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.



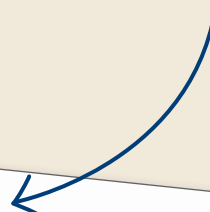
Volumetric flask

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SECTION 9



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



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 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.

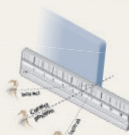


- 2 Read the volume on the scale of the graduated cylinder, with your eyes at the same height as the surface of the liquid so as to prevent parallax errors.



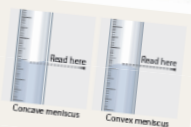
NOTE

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.



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SECTION 13

Scientific Methods for Testing a Hypothesis

13.1 MODELLING FOR REPRESENTING, EXPLAINING AND PREDICTING

Modelling involves constructing a concrete representation of an abstract situation that is difficult to observe or impossible to see. A model must:

- facilitate the understanding of a given reality
- explain certain properties of what it attempts to represent
- allow new phenomena to be predicted

The model can take different forms: a text, a drawing, a mathematical or chemical formula or equation, a computer simulation or a scale model.

Here are the different steps for modelling.

1 DEVELOP THE MODEL

- Identify the components and the relationships between them.
- Choose the method of representation.

2 BUILD THE MODEL

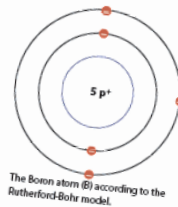
- Make a scale or diagram.
- Establish a formula.

3 VALIDATE THE MODEL

- Identify possible contradictions or inconsistencies.
- Verify the model's validity.
- Make changes or go back to the previous steps, if necessary.

EXAMPLE The Rutherford-Bohr model.

The atom is such a small structure that it is impossible to see it with the naked eye. Therefore, we use models to represent it. The Rutherford-Bohr atomic model illustrates the atom by showing the number of protons in the nucleus and the number of electrons in each of the electron shells. The Rutherford-Bohr model thus helps observers understand the atom, explains some of its properties and makes it possible to predict new phenomena.



The Boron atom (B) according to the Rutherford-Bohr model.

SECTION 13 - Scientific Methods for Testing a Hypothesis

173

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.

SECTION 9

- 4 Turn the selection knob clockwise to the 10A position. If the current value is lower than 0.2 in the 10A range, follow the procedure for measuring a direct current value between 0 and 200mA given below. If the multimeter reading is greater than 0.2, this means that the reading is as accurate as possible. If the multimeter displays "1" on the left-hand side of the screen, this means that you have exceeded the range. In this case, you cannot take the measurement since, as mentioned earlier, a multimeter cannot measure current of more than 10A.

To measure a direct current value less than 200mA:

1. plug the red probe of the multimeter into the VΩmA jack and the black probe into the COM jack;
2. disconnect the circuit at the point where you want to take the measurement;
3. insert the multimeter in series by connecting the two probes to the disconnected ends of the circuit.



- 5 If the current intensity being measured is known, turn the selection knob clockwise and set it to this position in the DCA range of the dial.
- 6 If the current intensity being measured is unknown, turn the selection knob clockwise to the 200m position in the DCA range. If the current is weak, the multimeter reading will be a very small number or zero. The range may have been set too high. Turn the selection knob counter-clockwise from the 200m position until the multimeter displays "1" on the left-hand side of the screen. This means that you have exceeded the range. Turn the selection knob back one position to obtain the most accurate measurement.

NOTE

If the device displays a "1" for all the ranges, check the connections. If the connections are correct, check whether the fuse has blown. If necessary, replace it.

144

PART 3 - Safety and Techniques

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

9.1 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. Use the other hand holding the bulb, the other hand holds the container with the liquid that is being collected or poured.

Procedure for use

- 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.
- 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.

SECTION 9 - Lab

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

- 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.
- 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.

SECTION 9 - Lab

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

9.2 MOLECULES AND SOLUTIONS

Pure substances and mixtures

A pure substance consists of only one type of particle. An element is a pure substance consisting of only one type of atom, bonded or independent, whereas a compound 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 (O₃) is a pure substance.
- Carbon dioxide (CO₂) is a compound made up of only one type of molecule.

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 chemical compounds is called chemical nomenclature.

Binary compounds are those that contain only two different elements. The element binary compound can contain more than two atoms, but no more than two different types of atoms.

The nomenclature is based on the following rules:

- If the compound is composed of a metal and a nonmetal, name the first element first (the name remains unchanged). Note that if the compound is composed 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 full compound H₂O. The element that appears first in the formula is hydrogen H. The element that appears second in the formula is oxygen O. It is referred to as "oxide." The compound is referred to as "hydrogen oxide."
- If the compound contains more than two atoms of one element, use a prefix to indicate the number of atoms of each element (e.g., carbon dioxide for CO₂). Note that there are exceptions to these rules, such as ferric oxide (Fe₂O₃).

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.
- MnO₂ is manganese dioxide.

9.3 CREATING A PROJECTION DRAWING

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

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.

Top view

Right view

Back view

Left view

Front view

Bottom view

9.4 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

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
Minerals 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)

GRAPHICS

Graphs translate numerical data into a visual image.

EXAMPLE

The solubility of certain substances as a function of temperature

SECTION 11 - Communication

EXAMPLE 2

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

$$A_l = A_b \times h$$

$$A_l = (5 \times 6) \times 11 \text{ cm}$$

$$A_l = 30 \text{ cm} \times 11 \text{ cm} = 330 \text{ cm}^2$$

EXAMPLE 3

To calculate the total area:

$$A_{\text{total}} = A_b + A_l$$

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

3.4 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 $V_{\text{cube}} = \text{side} \times \text{side} \times \text{side}$ $V_{\text{cube}} = s^3$	 $V_{\text{cube}} = (4 \text{ cm})^3 = 64 \text{ cm}^3$

Volume formulas

Volume of a prism

$$V_{\text{prism}} = \text{area of one base} \times \text{height}$$

$$V_{\text{prism}} = A_b \times h$$

Volume of a pyramid

$$V_{\text{pyramid}} = \frac{\text{area of base} \times \text{height}}{3}$$

$$V_{\text{pyramid}} = \frac{A_b \times h}{3}$$

Volume of a sphere

$$V_{\text{sphere}} = \frac{4 \times \pi \times \text{radius} \times \text{radius} \times \text{radius}}{3}$$

$$V_{\text{sphere}} = \frac{4\pi r^3}{3}$$

Example

$$V_{\text{prism}} = \frac{4 \text{ cm} \times 3 \text{ cm} \times 5}{2} = 6 \text{ cm} = 180 \text{ cm}^3$$

$$V_{\text{pyramid}} = \frac{5 \text{ cm} \times 5 \text{ cm} \times 6 \text{ cm}}{3} = 50 \text{ cm}^3$$

$$V_{\text{sphere}} = \frac{4 \times \pi \times (3 \text{ cm})^3}{3} = 113.1 \text{ cm}^3$$

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

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

SECTION 5

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 (g) or by the burning of forests (b).

Carbon sources and carbon sinks

SECTION 5

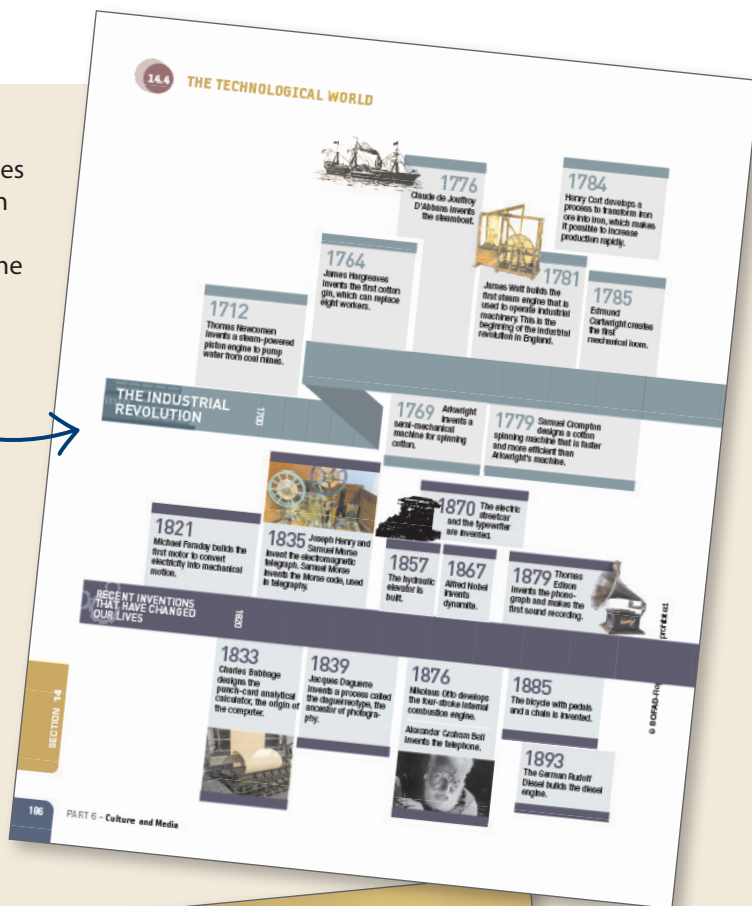
The phosphorus cycle and eutrophication

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 stages 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 waste 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).

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



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.



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- The Living World

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- Workshop techniques
- Laboratory techniques

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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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