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# Information Document

## MINISTERIAL EXAMINATIONS

### Secondary IV

|                                |         |
|--------------------------------|---------|
| Science and Technology         | 555-410 |
| Applied Science and Technology | 557-410 |

January 2026 – June 2026 – August 2026

**Coordination and content**

Direction de l'évaluation des apprentissages  
Direction générale de la formation générale des jeunes et des adultes  
Secteur de la réussite éducative et de la main-d'œuvre

**Title of original document**

*Document d'information – Épreuves ministérielles – 4<sup>e</sup> année du secondaire  
Science et technologie (055-410)  
Applications technologiques et scientifiques (057-410)  
Janvier 2026 – Juin 2026 – Août 2026*

**English version**

Services linguistiques en anglais  
Direction du soutien au réseau éducatif anglophone  
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Ministère de l'Éducation

ISSN 1927-8578 (Online)  
ISSN 1927-8535 (French, online)

Legal Deposit – Bibliothèque et Archives nationales du Québec, 2025

25-157-07

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## INTRODUCTION

This document provides information on the ministerial examinations for the Secondary IV science programs, namely Science and Technology (ST), and Applied Science and Technology (AST). Among other things, this document was designed to guide teachers in the preparatory work they must do throughout the year to ensure that their students can pass these examinations.

The Ministère de l'Éducation is responsible for developing examinations for the *Theory* component of each program. These exams will be administered in January, June and August. The *Theory* component focuses on the development of the following competencies: *Makes the most of [their] knowledge of science and technology* and *Communicates in the languages used in science and technology*.

Each examination is based on the Framework for the Evaluation of Learning ([ST](#) or [AST](#)), the Progression of Learning ([ST](#) or [AST](#)) and the Québec Education Program ([ST](#) or [AST](#)). Information gathered on examinations administered in previous years is also taken into account in the development of examinations. In addition, the Ministère enlists teachers and education consultants representing different schools to contribute to this process. The [Support Document](#) provides additional information on the compulsory concepts on which students may be tested in the Secondary IV ministerial examinations for Science and Technology and Applied Science and Technology.

Educational institutions must administer each ministerial examination in accordance with the [official schedule](#).

The examinations for the *Practical* component are developed by educational institutions. Prototype examinations for the experimental method and the technological design process, which are intended to help teachers become familiar with the evaluation process for the *Practical* component, are available on a secure site of the Ministère.<sup>1</sup> The use of the rubrics in these prototypes is recommended for any evaluation carried out during the school year.

For the 2025-2026 school year, the weighting assigned to the Secondary IV and V ministerial examinations will be 50% for the competency or competencies evaluated.

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1. To obtain the documents found on the secure site, teachers are invited to contact the person in charge of the certification of studies at their educational institution.

## 1. ELEMENTS TO BE EVALUATED

### 1.1 Evaluation criteria

The evaluation criteria for each ministerial examination are as follows:

- Proficiency in subject-specific knowledge targeted in the Progression of Learning
- Relevant use of scientific and technological knowledge
- Appropriate formulation of explanations or solutions

### 1.2 Additional information on the compulsory concepts

The compulsory concepts on which students may be tested in the ministerial examinations for Science and Technology and Applied Science and Technology are indicated in Appendices I and II.

The Ministère has decided not to include concepts related to The Living World in the above-mentioned examinations. As these concepts can be tested more effectively at the local level than by means of ministerial examinations, educational institutions are entirely responsible for evaluation in this regard. An analysis of student answers on past examinations and teachers' comments have revealed that the variety of settings encountered in the different regions of Québec has an impact on the answers given to questions on concepts related to The Living World. For example, students living in urban, forest or rural areas experience their respective environments in specific ways, which may sometimes result in different interpretations of the realities presented in these questions.

However, because environmental issues are an integral part of the knowledge students develop in this subject, they are incorporated into questions related to the other major areas. For example, a situation involving a human disturbance, such as a toxic spill, would be particularly suitable for measuring students' comprehension of the concepts of catchment area and watershed divide. Other situations related to The Living World, and ecology in particular, could also be used in the ministerial examinations.

### 1.3 Proficiency in knowledge and the ability to use it

Proficiency in knowledge means that students are able to carry out a written task that shows that they know and understand a concept (element, operation, relationship, model) related to science and technology. The ability to use knowledge means that students are capable of applying a combination of concepts (elements, operations, relationships, models) related to science and technology. The questions relating to the students' proficiency in knowledge and ability to use it may be multiple-choice or constructed-response questions and may involve one of the following:

- Identification or understanding of a concept
- Identification or formulation of examples pertaining to a concept
- Simple application of a formula or an idea related to a concept
- Understanding of a combination of concepts
- Application of a complex procedure
- Explanation or justification of one or more concepts that may require analysis

## 2. CONTENT OF THE EXAMINATIONS

### 2.1 Science and Technology (555-410)

The examination for Science and Technology requires students to analyze situations and a technical object. Working alone, students must solve various problems using their knowledge of the compulsory concepts in three of the four major areas of the program.

The examination, which consists of 25 questions worth 4 marks each, is divided into three parts.

- Part A consists of 15 multiple-choice questions worth 60% of the examination mark. These questions evaluate students' proficiency in or ability to use knowledge relating to the compulsory concepts.
- Part B consists of 5 constructed-response questions worth 20% of the examination mark.
- Part C consists of 5 questions on the technological analysis of a technical object and is worth 20% of the examination mark.

The examination consists of:

- a Student Booklet
- a Reference Document, which includes the list of formulas and quantities, the periodic table of the elements, and the diagrams of the technical object
- an answer sheet for the multiple-choice questions (for the January and August examinations)
- a scannable answer sheet for the multiple-choice questions (for the June examination)
- a visual aid (a video animation showing how a technical object works)
- a Marking Guide for teachers
- Instructions for the Invigilator

**Distribution of Questions in Each Major Area of the Science and Technology Program and Related Weighting**

| Part         | Number of Questions | The Living World | The Earth and Space | The Material World | The Technological World | Weighting |
|--------------|---------------------|------------------|---------------------|--------------------|-------------------------|-----------|
| <b>A</b>     | 15                  | ---              | 4                   | 10                 | 1                       | 60%       |
| <b>B</b>     | 5                   | ---              | 1                   | 3                  | 1                       | 20%       |
| <b>C</b>     | 5                   | ---              | ---                 | ---                | 5                       | 20%       |
| <b>Total</b> | 25                  | ---              | 5<br>(20%)          | 13<br>(52%)        | 7<br>(28%)              | 100%      |

## 2.2 Applied Science and Technology (557-410)

The examination for Applied Science and Technology requires students to analyze situations and a technical object. Working alone, students must solve various problems using their knowledge of the compulsory concepts in three of the four major areas of the program.

The examination, which consists of 25 questions worth 4 marks each, is divided into three parts.

- Part A consists of 15 multiple-choice questions worth 60% of the examination mark. These questions evaluate students' proficiency in or ability to use knowledge relating to the compulsory concepts.
- Part B consists of 4 constructed-response questions worth 16% of the examination mark.
- Part C consists of 6 questions on the technological analysis of a technical object and is worth 24% of the examination mark.

The examination consists of:

- a Student Booklet
- a Reference Document, which includes the list of formulas and quantities and the diagrams of the technical object
- an answer sheet for the multiple-choice questions (for the January and August examinations)
- a scannable answer sheet for the multiple-choice questions (for the June examination)
- a visual aid (a video animation showing how a technical object works)
- a Marking Guide for teachers
- Instructions for the Invigilator

**Distribution of Questions in Each Major Area of the  
Applied Science and Technology Program and Related Weighting**

| Part         | Number of Questions | The Living World | The Earth and Space | The Material World | The Technological World | Weighting |
|--------------|---------------------|------------------|---------------------|--------------------|-------------------------|-----------|
| <b>A</b>     | 15                  | ---              | 1                   | 9                  | 5                       | 60%       |
| <b>B</b>     | 4                   | ---              | 1                   | 2                  | 1                       | 16%       |
| <b>C</b>     | 6                   | ---              | ---                 | ---                | 6                       | 24%       |
| <b>Total</b> | 25                  | ---              | 2<br>(8%)           | 11<br>(44%)        | 12<br>(48%)             | 100%      |

### 3. CONDITIONS FOR ADMINISTERING THE EXAMINATIONS

#### 3.1 Time allotted

The official schedule indicates that the duration of the examinations is 3 hours. However, an additional 15 minutes must be allotted, if needed, as provided for under section 4.3.7 of the [Administrative Guide for the Certification of Studies and Management of Ministerial Examinations](#).

#### 3.2 Procedure

Students must work alone, considering questions and analyzing problems that test their knowledge or their ability to use it. They must also analyze different aspects of a technical object. A video animation showing the workings of the technical object to be analyzed must play continuously during the examination. Since each of the three parts of the examination can stand alone, students can start by answering the questions in any part they so choose.

Students must first read through the examination questions and reference materials presented in the Student Booklet and the Reference Document. They must then record all their answers to the questions in Part A on the answer sheet and show all the relevant work related to the questions in Parts B and C in the Student Booklet.

The educational institution must ensure that the examination room has the equipment for showing the video animation and that each student has a clear view of it.

While viewing the video animation of the technical object, students are forbidden to communicate with one another or to ask a school staff member questions.

In the interests of equity and justice, the examination must be administered under the same conditions to all students across Québec. It is thus forbidden for anyone to help students in any way, for example by clarifying a question or rewording instructions. Examinations in which a teacher or any other school staff member is deemed to have overstepped the boundaries of their role may be declared invalid by the Ministère.

It is forbidden to disclose any information about the content of a ministerial examination to anyone who is not directly involved in its administration. It is also forbidden to distribute, adapt or translate any examination document, in whole or in part, at any time or by any means whatsoever, including social media.



### 3.3 Authorized materials

Only the following materials may be used during the examination:

- Ruler
- Calculator with or without a graphic display

### 3.4 Rules for using calculators or other materials

Prior to the examination, students must be duly informed, in writing, of the rules regarding the use of calculators during a ministerial examination.

#### Rules for using calculators

Calculators with or without a graphic display may be used during the ministerial examinations for Secondary IV Science and Technology, and Applied Science and Technology.

Calculators with a computer algebra system (CAS) are permitted only if this system is disabled for the entire examination.

In the interest of fairness regarding applications in a computer, tablet or calculator, certain functions must be disabled or monitored. Further details are provided by the Direction de la sanction des études.

The data and programs stored in the calculator's memory must be deleted before the examination begins. Students must therefore have been given the opportunity beforehand to learn how to reset their calculator's memory. In addition, it is forbidden to store programs and data libraries in the calculator's memory during the examination.

User guides, memory expansion features or any other calculator accessories or peripherals are not allowed during the examination. Communication between calculators is also not permitted during the examination.

If, during the examination, a student is caught in possession of a calculator whose memory contains data or programs, this will be considered a form of cheating, and the student will receive a mark of 0% on the examination.

Students may not lend their calculator to other students or borrow one from them.

During the examination, students are strictly forbidden to have in their possession any personal mobile device (smartphone, wireless headphones or earbuds, smartwatch, etc.).

Any student who is caught in possession of unauthorized materials during the examination will be expelled from the examination room for cheating and will receive a mark of 0% on the examination. This rule applies even if a student who is found in possession of a personal mobile device is not using the device or has turned it off.

### **3.5 Adaptation measures**

Measures that adapt the conditions for administering ministerial examinations may be taken to enable students with specific needs to demonstrate their learning. For further information on the implementation of these measures, please refer to the documents made available to schools by the Direction de la sanction des études.

## **4. MARKING PROCEDURES FOR THE EXAMINATIONS**

### **4.1 Responsibility for marking the examinations**

With respect to the June examinations, Part A will be marked by the Ministère, and Parts B and C will be marked by educational institutions. Every part (A, B and C) of the January and August examinations will be marked by educational institutions.

### **4.2 Marking tools**

In marking the examination papers, teachers must refer to the instructions in the Marking Guide provided by the Ministère and should form a marking committee to ensure that they have a common understanding of these instructions. By analyzing some of the examination papers submitted, the committee will be better able to determine what is expected of students.

## **5. STUDENT'S RESULT ON THE EXAMINATION**

The result obtained on either of the examinations is expressed as a mark out of 100 and is the sum of the marks for each of Parts A, B and C.

### **5.1 June examinations**

Once Parts B and C have been marked by educational institutions, the scannable answer sheets and the Student Booklets must be sent to the Direction de la sanction des études, in accordance with the established procedures. All calculations for determining the final result for the June examinations are carried out by the Ministère.

### **5.2 January and August examinations**

All questions on the January and August examinations are marked by educational institutions. Details on how to send the results for these examinations are specified by the Direction de la sanction des études.

## APPENDIX I

### Compulsory Concepts on Which Students May Be Tested in the Science and Technology Ministerial Examinations (555-410)

The scope of each concept is defined in the Progression of Learning.

The following are also evaluated: Techniques related to diagram drawing and graphic representation (isometric representation, perspective drawing).

| The Earth and Space                                                                                                                                                                                                                                                                                                     | The Material World                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                | The Technological World                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |
|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Biogeochemical cycles</b><br>– Carbon cycle<br><br><b>Lithosphere</b><br>– Permafrost<br>– Energy resources<br><br><b>Hydrosphere</b><br>– Catchment area<br>– Ocean circulation<br>– Glacier and pack ice<br>– Salinity<br>– Energy resources<br><br><b>Atmosphere</b><br>– Greenhouse effect<br>– Energy resources | <b>Physical properties of solutions</b><br>– Concentration (g/L, %, ppm)<br>– pH scale<br>– Ions<br>– Electrical conductivity<br><br><b>Chemical changes</b><br>– Combustion<br>– Photosynthesis and respiration<br>– Acid-base neutralization reaction<br>– Balancing chemical equations<br>– Law of conservation of mass<br><br><b>Organization of matter</b><br>– Rutherford-Bohr atomic model<br>– Groups and periods in the periodic table<br><br><b>Electricity</b><br>– Electrical charge<br>– Static electricity<br>– Ohm's law<br>– Electrical circuits<br>– Relationship between power and electrical energy<br><br><b>Electromagnetism</b><br>– Forces of attraction and repulsion<br>– Magnetic field of a live wire<br><br><b>Transformation of energy</b><br>– Law of conservation of energy<br>– Energy efficiency | <b>Mechanical engineering</b><br>– Characteristics of the linking of mechanical parts<br>– Guiding controls<br>– Construction and characteristics of motion transmission systems (friction gears, pulleys and belt, gear assembly, sprocket wheels and chain, wheel and worm gear)<br>– Speed changes<br>– Construction and characteristics of motion transformation systems (screw gear system, cams, connecting rods, cranks, slides and rotating slider crank mechanisms, rack-and-pinion drive)<br><br><b>Electrical engineering</b><br>– Power supply<br>– Conduction, insulation and protection<br>– Control<br>– Transformation of energy (electricity, light, heat, vibration, magnetism)<br><br><b>Materials</b><br>– Constraints<br>– Characteristics of mechanical properties<br>– Types and properties<br>– Plastics (thermoplastics, thermosetting plastics)<br>– Ceramics<br>– Modification of properties (degradation, protection) |

## Compulsory Concepts on Which Students May Be Tested in the Applied Science and Technology Ministerial Examinations (557-410)

The scope of each concept is defined in the Progression of Learning.

The following are also evaluated: Techniques related to diagram drawing and graphic representation (multiview orthogonal projection, isometric representation, perspective drawing), use of scales.

| The Earth and Space                                                                                                                                                                                                                                        | The Material World                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           | The Technological World                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |
|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Lithosphere</b><br>– Energy resources<br><br><b>Hydrosphere</b><br>– Catchment area<br>– Energy resources<br><br><b>Atmosphere</b><br>– Cyclone and anticyclone<br>– Energy resources<br><br><b>Space</b><br>– Earth-Moon system (gravitational effect) | <b>Chemical changes</b><br>– Combustion<br>– Oxidation<br><br><b>Electricity</b><br>– Electrical charge<br>– Static electricity<br>– Ohm's law<br>– Electrical circuits<br>– Relationship between power and electrical energy<br><br><b>Electromagnetism</b><br>– Forces of attraction and repulsion<br>– Magnetic field of a live wire<br>– Magnetic field of a solenoid<br>– Electromagnetic induction<br><br><b>Transformation of energy</b><br>– Law of conservation of energy<br>– Energy efficiency<br><br><b>Fluids</b><br>– Archimedes' principle<br>– Pascal's principle<br>– Bernoulli's principle<br><br><b>Forces and motion</b><br>– Force<br>– Types of forces<br>– Equilibrium of two forces<br>– Relationship between constant speed, distance and time<br>– Mass and weight | <b>Graphical language</b><br>– Multiview orthogonal projection (general drawing)<br>– Functional dimensioning<br>– Developments (prism, cylinder, pyramid, cone)<br>– Standards and representations (diagrams, symbols)<br><br><b>Mechanical engineering</b><br>– Adhesion and friction of parts<br>– Linking of mechanical parts (degree of freedom of a part)<br>– Guiding controls<br>– Construction and characteristics of motion transmission systems (friction gears, pulleys and belt, gear assembly, sprocket wheels and chain, wheel and worm gear)<br>– Speed changes<br>– Construction and characteristics of motion transformation systems (screw gear system, connecting rods, cranks, slides, cams, eccentrics and rotating slider crank mechanisms, rack-and-pinion drive)<br><br><b>Electrical engineering</b><br>– Power supply<br>– Conduction, insulation and protection (resistance and coding)<br>– Control [types: unipolar (single-pole), unidirectional (single-throw), bidirectional (double-throw)]<br>– Transformation of energy (electricity, light, heat, vibration, magnetism)<br>– Other functions [capacitor (condenser), diode, relay]<br><br><b>Materials</b><br>– Constraints<br>– Characteristics of mechanical properties<br>– Types and properties<br>– Plastics (thermoplastics, thermosetting plastics)<br>– Ceramics<br>– Modification of properties (degradation, protection)<br><br><b>Manufacturing</b><br>– Manufacturing (characteristics of drilling, tapping, threading and bending) |

## APPENDIX III

## PERIODIC TABLE OF THE ELEMENTS

| PERIODIC TABLE OF THE ELEMENTS |                               |                                                                                                                    |                               |                                     |                                |                                    |                                 |                                 |                                  |                                    |                                   |                                   |                                  |                                  |                                 |                                   |                                  |                                  |
|--------------------------------|-------------------------------|--------------------------------------------------------------------------------------------------------------------|-------------------------------|-------------------------------------|--------------------------------|------------------------------------|---------------------------------|---------------------------------|----------------------------------|------------------------------------|-----------------------------------|-----------------------------------|----------------------------------|----------------------------------|---------------------------------|-----------------------------------|----------------------------------|----------------------------------|
| I A<br>1                       |                               | Key                                                                                                                |                               |                                     |                                |                                    |                                 |                                 |                                  |                                    |                                   | VIII A<br>18                      |                                  |                                  |                                 |                                   |                                  |                                  |
| 1                              | 1<br>H<br>hydrogen<br>1.01    | <div>Element symbol</div> <div>1<br/>H<br/>hydrogen<br/>1.01</div> <div>Atomic number</div> <div>Atomic mass</div> |                               |                                     |                                |                                    |                                 |                                 |                                  |                                    |                                   |                                   |                                  |                                  |                                 |                                   |                                  |                                  |
| II A<br>2                      |                               |                                                                                                                    |                               |                                     |                                |                                    |                                 |                                 |                                  |                                    |                                   | III A<br>13                       | IV A<br>14                       | V A<br>15                        | VI A<br>16                      | VII A<br>17                       |                                  |                                  |
| 2                              | 3<br>Li<br>lithium<br>6.94    | 4<br>Be<br>beryllium<br>9.01                                                                                       |                               |                                     |                                |                                    |                                 |                                 |                                  |                                    |                                   |                                   | 5<br>B<br>boron<br>10.81         | 6<br>C<br>carbon<br>12.01        | 7<br>N<br>nitrogen<br>14.01     | 8<br>O<br>oxygen<br>16.00         | 9<br>F<br>fluorine<br>19.00      | 10<br>Ne<br>neon<br>20.18        |
| 3                              | 11<br>Na<br>sodium<br>22.99   | 12<br>Mg<br>magnesium<br>24.31                                                                                     | III B<br>3                    | IV B<br>4                           | V B<br>5                       | VI B<br>6                          | VII B<br>7                      | VIII B<br>8 9 10                |                                  |                                    | I B<br>11                         | II B<br>12                        | 13<br>Al<br>aluminum<br>26.98    | 14<br>Si<br>silicon<br>28.09     | 15<br>P<br>phosphorus<br>30.97  | 16<br>S<br>sulphur<br>32.07       | 17<br>Cl<br>chlorine<br>35.45    | 18<br>Ar<br>argon<br>39.95       |
| 4                              | 19<br>K<br>potassium<br>39.10 | 20<br>Ca<br>calcium<br>40.08                                                                                       | 21<br>Sc<br>scandium<br>44.96 | 22<br>Ti<br>titanium<br>47.90       | 23<br>V<br>vanadium<br>50.94   | 24<br>Cr<br>chromium<br>52.00      | 25<br>Mn<br>manganese<br>54.94  | 26<br>Fe<br>iron<br>55.85       | 27<br>Co<br>cobalt<br>58.93      | 28<br>Ni<br>nickel<br>58.71        | 29<br>Cu<br>copper<br>63.55       | 30<br>Zn<br>zinc<br>65.39         | 31<br>Ga<br>gallium<br>69.72     | 32<br>Ge<br>germanium<br>72.59   | 33<br>As<br>arsenic<br>74.92    | 34<br>Se<br>selenium<br>78.96     | 35<br>Br<br>bromine<br>79.90     | 36<br>Kr<br>krypton<br>83.80     |
| 5                              | 37<br>Rb<br>rubidium<br>85.47 | 38<br>Sr<br>strontium<br>87.62                                                                                     | 39<br>Y<br>yttrium<br>88.91   | 40<br>Zr<br>zirconium<br>91.22      | 41<br>Nb<br>niobium<br>92.91   | 42<br>Mo<br>molybdenum<br>95.94    | 43<br>Tc<br>technetium<br>98.91 | 44<br>Ru<br>ruthenium<br>101.07 | 45<br>Rh<br>rhodium<br>102.91    | 46<br>Pd<br>palladium<br>106.40    | 47<br>Ag<br>silver<br>107.87      | 48<br>Cd<br>cadmium<br>112.41     | 49<br>In<br>indium<br>114.82     | 50<br>Sn<br>tin<br>118.71        | 51<br>Sb<br>antimony<br>121.75  | 52<br>Te<br>tellurium<br>127.60   | 53<br>I<br>iodine<br>126.90      | 54<br>Xe<br>xenon<br>131.30      |
| 6                              | 55<br>Cs<br>caesium<br>132.91 | 56<br>Ba<br>barium<br>137.33                                                                                       | 57-71<br>lanthanoids          | 72<br>Hf<br>hafnium<br>178.49       | 73<br>Ta<br>tantalum<br>180.95 | 74<br>W<br>tungsten<br>183.85      | 75<br>Re<br>rhenium<br>186.21   | 76<br>Os<br>osmium<br>190.20    | 77<br>Ir<br>iridium<br>192.22    | 78<br>Pt<br>platinum<br>195.09     | 79<br>Au<br>gold<br>196.97        | 80<br>Hg<br>mercury<br>200.59     | 81<br>Tl<br>thallium<br>204.37   | 82<br>Pb<br>lead<br>207.20       | 83<br>Bi<br>bismuth<br>208.98   | 84<br>Po<br>polonium<br>(209)     | 85<br>At<br>astatine<br>(210)    | 86<br>Rn<br>radon<br>(222)       |
| 7                              | 87<br>Fr<br>francium<br>(223) | 88<br>Ra<br>radium<br>(226)                                                                                        | 89-103<br>actinoids           | 104<br>Rf<br>rutherfordium<br>(267) | 105<br>Db<br>dubnium<br>(268)  | 106<br>Sg<br>seaborgium<br>(271)   | 107<br>Bh<br>bohrium<br>(272)   | 108<br>Hs<br>hassium<br>(270)   | 109<br>Mt<br>meitnerium<br>(276) | 110<br>Ds<br>darmstadtium<br>(281) | 111<br>Rg<br>roentgenium<br>(280) | 112<br>Cn<br>copernicium<br>(285) | 113<br>Nh<br>nihonium<br>(284)   | 114<br>Fl<br>flerovium<br>(289)  | 115<br>Mc<br>moscovium<br>(288) | 116<br>Lv<br>livermorium<br>(293) | 117<br>Ts<br>tennessine<br>(292) | 118<br>Og<br>oganeson<br>(294)   |
|                                |                               |                                                                                                                    |                               |                                     |                                |                                    |                                 |                                 |                                  |                                    |                                   |                                   |                                  |                                  |                                 |                                   |                                  |                                  |
|                                |                               |                                                                                                                    | 6                             | 57<br>La<br>lanthanum<br>138.91     | 58<br>Ce<br>cerium<br>140.12   | 59<br>Pr<br>praseodymium<br>140.91 | 60<br>Nd<br>neodymium<br>144.24 | 61<br>Pm<br>promethium<br>(145) | 62<br>Sm<br>samarium<br>150.36   | 63<br>Eu<br>europium<br>151.96     | 64<br>Gd<br>gadolinium<br>157.25  | 65<br>Tb<br>terbium<br>158.93     | 66<br>Dy<br>dysprosium<br>162.50 | 67<br>Ho<br>holmium<br>164.93    | 68<br>Er<br>erbium<br>167.26    | 69<br>Tm<br>thulium<br>168.93     | 70<br>Yb<br>ytterbium<br>173.05  | 71<br>Lu<br>lutetium<br>174.97   |
|                                |                               |                                                                                                                    | 7                             | 89<br>Ac<br>actinium<br>(227)       | 90<br>Th<br>thorium<br>232.04  | 91<br>Pa<br>protactinium<br>231.04 | 92<br>U<br>uranium<br>238.03    | 93<br>Np<br>neptunium<br>(237)  | 94<br>Pu<br>plutonium<br>(244)   | 95<br>Am<br>americium<br>(243)     | 96<br>Cm<br>curium<br>(247)       | 97<br>Bk<br>berkelium<br>(247)    | 98<br>Cf<br>californium<br>(251) | 99<br>Es<br>einsteinium<br>(252) | 100<br>Fm<br>fermium<br>(257)   | 101<br>Md<br>mendelevium<br>(258) | 102<br>No<br>nobelium<br>(259)   | 103<br>Lr<br>lawrencium<br>(262) |

## FORMULAS AND QUANTITIES

### Science and Technology

| FORMULAS                                                                                                             |                                                                                                 |
|----------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------|
| $C = \frac{m}{V}$<br>C : concentration<br>m : quantity of solute<br>V : quantity of solution                         | $P = V I$<br>P : electrical power<br>V : potential difference<br>I : electric current intensity |
| $V = R I$<br>V : potential difference<br>R : resistance<br>I : electric current intensity                            | $E = P \Delta t$<br>E : energy consumed<br>P : electrical power<br>$\Delta t$ : time difference |
| $\text{Energy efficiency (\%)} = \frac{\text{Amount of useful energy}}{\text{Amount of energy consumed}} \times 100$ |                                                                                                 |

| QUANTITIES       |        |                                                            |
|------------------|--------|------------------------------------------------------------|
| NAME             | SYMBOL | VALUE                                                      |
| Density of water | $\rho$ | 1.0 g/mL<br>or<br>1.0 kg/L<br>or<br>1000 kg/m <sup>3</sup> |
| Kilowatt hour    | kW•h   | 1 kW•h = 3 600 000 J                                       |

## APPENDIX V

## FORMULAS AND QUANTITIES

### Applied Science and Technology

| FORMULAS                                                                                                             |                                                                                                                                                                                                                                                                           |
|----------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| $V = R I$<br>$P = V I$<br>$E = P \Delta t$                                                                           | $V$ : potential difference<br>$R$ : resistance<br>$I$ : electric current intensity<br><br>$P$ : electrical power<br>$V$ : potential difference<br>$I$ : electric current intensity<br><br>$E$ : energy consumed<br>$P$ : electrical power<br>$\Delta t$ : time difference |
|                                                                                                                      | $F_g = m g$<br>$v = \frac{d}{\Delta t}$                                                                                                                                                                                                                                   |
|                                                                                                                      | $F_g$ : gravitational force<br>$m$ : mass<br>$g$ : intensity of the gravitational field<br><br>$v$ : speed<br>$d$ : distance<br>$\Delta t$ : time difference                                                                                                              |
| $\text{Energy efficiency (\%)} = \frac{\text{Amount of useful energy}}{\text{Amount of energy consumed}} \times 100$ |                                                                                                                                                                                                                                                                           |

| QUANTITIES                                    |                          |                                                   |
|-----------------------------------------------|--------------------------|---------------------------------------------------|
| NAME                                          | SYMBOL                   | VALUE                                             |
| Intensity of the gravitational field on Earth | $g$                      | 9.8 N/kg                                          |
| Kilowatt hour                                 | $\text{kW}\cdot\text{h}$ | 1 $\text{kW}\cdot\text{h} = 3\,600\,000\text{ J}$ |

