



# INFORMATION DOCUMENT

Uniform Examinations

Secondary IV

January 2022 – June 2022 – August 2022

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Applied Science and Technology 557-410

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## INTRODUCTION

This information document outlines the main components of the uniform 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 producing uniform examinations for the *Theory* component of each program. These exams will be administered in January, June and August.

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 addition, the Ministère enlists teachers and education consultants representing different schools to contribute to the development of each examination.

Schools must administer each uniform examination at the appointed time in the [official schedule](#) for each examination session.

The examinations for the *Practical* component are developed by educational institutions. However, these examinations must take into account the instructions in this document in order to ensure a measure of uniformity. It should be noted that the prototype examinations for the experimental method and technological design process were updated during the 2013-2014 school year. These examinations are intended to help teachers become familiar with the evaluation process for the *Practical* component and are available on a secure website of the Ministère.

### Information Specific to the Examinations for the 2021-2022 School Year

The uniform examinations are in line with the [Learning to Be Prioritized at the Secondary Level for the 2021-2022 School Year in the Context of the Pandemic](#).

The compulsory concepts on which students may be tested in the examinations are indicated in Appendices I and II of this document.

The weighting assigned to uniform examinations has been reduced to 20%. Clarifications in this regard are provided in Section 7.

## 1. ELEMENTS TO BE EVALUATED

### 1.1 Evaluation Criteria

The evaluation criteria for each uniform 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 January, June and August 2022 ministerial examinations for Science and Technology and Applied Science and Technology are indicated in Appendices I and II. It should be noted that these concepts are in line with the *Learning to Be Prioritized at the Secondary Level for the 2021-2022 School Year in the Context of the Pandemic*.

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 examination.

### 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 UNIFORM EXAMINATIONS

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

The uniform 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, which evaluate students' proficiency in or ability to use knowledge relating to the compulsory concepts, are presented in the Question Booklet.
- Part B consists of 5 constructed-response questions worth 20% of the examination mark. These questions are presented in the Student Booklet.
- Part C consists of 5 questions on the technological analysis of a technical object and is worth 20% of the examination mark. These questions are also presented in the Student Booklet.

The examination consists of:

- a Question Booklet
- 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
- a scannable answer sheet (for the June examination)
- a visual aid (an animated video showing how a technical object works)
- a Marking Guide for teachers
- Instructions for the Person in Charge of the Administration of Ministerial Examinations in the School
- Instructions for the Invigilator

The animated video showing how the technical object works will be available on the secure website of the Direction de la sanction des études. It can be provided on a DVD to educational institutions that request it.

**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 (20%)	13 (52%)	7 (28%)	100%

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

The uniform 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, which evaluate students' proficiency in or ability to use knowledge relating to the compulsory concepts, are presented in the Question Booklet.
- Part B consists of 4 constructed-response questions worth 16% of the examination mark. These questions are presented in the Student Booklet.
- Part C consists of 6 questions on the technological analysis of a technical object and is worth 24% of the examination mark. These questions are also presented in the Student Booklet.

The examination consists of:

- a Question Booklet
- a Student Booklet
- a Reference Document, which includes the list of formulas and quantities, and the diagrams of the technical object
- a scannable answer sheet (for the June examination)
- a visual aid (an animated video showing how a technical object works)
- a Marking Guide for teachers
- Instructions for the Person in Charge of the Administration of Ministerial Examinations in the School
- Instructions for the Invigilator

The animated video showing how the technical object works will be available on the secure website of the Direction de la sanction des études. It can be provided on a DVD to educational institutions that request it.

**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 (8%)	11 (44%)	12 (48%)	100%

### 3. CONDITIONS FOR ADMINISTERING THE UNIFORM EXAMINATIONS

#### 3.1 Duration of the Examinations

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 \(2015 edition\)](#).

#### 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. An animated video 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 Question Booklet, the Student Booklet and the Reference Document. They must then answer the questions in the Student Booklet and on the scannable answer sheet (for the June examinations) by carrying out all the work according to the instructions provided.

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

While viewing the animated video 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, or to distribute any examination document, in whole or in part, at any time or by any means whatsoever, including social media.



### 3.3 Authorized Materials

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

Only the following materials may be used during the examination:

- Ruler
- Calculator with or without a graphic display

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

Only the following materials may be used during the examination:

- Ruler
- Calculator with or without a graphic display

#### 3.3.3 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 uniform examinations for Secondary IV Science and Technology, and Applied Science and Technology.

Certain digital tools (such as an application with features equivalent to those permitted in a calculator) may be used under certain conditions. Further details will be provided by the Direction de la sanction des études.

The data and programs stored in the calculator's memory must be erased 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 examination may be declared invalid by the Ministère.

Students may not lend their calculator to other students.

During the examination, students are strictly forbidden to have in their possession any digital device (smartphone, wireless headphones or earbuds, smartwatch, etc.) that can be used to communicate, access the Internet, translate text, or create, save or consult data.

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 digital device is not using the device or has turned it off.

### **3.4 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 THE UNIFORM 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 grading 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. RESULTS ON THE UNIFORM EXAMINATIONS**

The result obtained on either of the uniform examinations is expressed as a mark out of 100 and is the sum of the results 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 must be sent to the Direction de la sanction des études. All calculations for determining the final mark 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 submit the results for these examinations will be specified at a later date by the Direction de la sanction des études.

## 6. EVALUATION OF THE *PRACTICAL* COMPONENT

With regard to the *Practical* component, teachers must evaluate student learning by means of examinations in a laboratory or workshop. These examinations involve the experimental method or the technological design process. This component, which is administered and marked by educational institutions, is calculated out of 100 and counts for 40% of the student's subject mark.

It is not advisable to use a single examination per year to evaluate the *Practical* component, as that would entail deriving 40% of the student's final mark from a single evaluation situation. To obtain meaningful results, it is recommended that students be evaluated on an individual basis each term.

Rubrics for evaluating students' work on practical examinations involving the experimental method and the technological design process are included in the prototype examinations available on a secure website of the Ministère. It is a good idea to use these rubrics throughout the year.

## 7. SUBJECT MARK AND MINIMUM PERFORMANCE STANDARD

The subject mark is based on the result for each component, weighted in accordance with the percentages established by the Ministère and presented in the Framework for the Evaluation of Learning. Students earn credits for the program if they obtain a subject mark of at least 60%.

Owing to exceptional circumstances, the student's mark on the uniform examination for the 2021-2022 school year will count for 20% of the final mark for the theory component, instead of the usual 50%. Therefore, the moderated school mark will be worth 80% of the final mark. In accordance with the Framework for the Evaluation of Learning, this component counts for 60% of the subject mark.

The weighting for the two components is the same for both the Science and Technology program and the Applied Science and Technology program.

*Practical* component: 40% (school mark only)

*Theory* component: 60% (48% for the moderated school mark and 12% for the uniform examination mark)

Additional information in this regard is available in the [Processing of results](#) section on the Ministère's website.

**Compulsory Concepts on Which Students  
May Be Tested in the Science and Technology Examinations (555-410)  
for the 2021-2022 School Year**

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

Given the exceptional circumstances, students will not be tested on the concepts of *carbon cycle*, *law of conservation of energy* and *energy efficiency* in the 2021-2022 ministerial examinations. This adjustment is intended to ensure consistency with the *Learning to Be Prioritized at the Secondary Level for the 2021-2022 School Year in the Context of the Pandemic*.

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
<p><b>Lithosphere</b></p> <ul style="list-style-type: none"> <li>– Permafrost</li> <li>– Energy resources</li> </ul> <p><b>Hydrosphere</b></p> <ul style="list-style-type: none"> <li>– Catchment area</li> <li>– Ocean circulation</li> <li>– Glacier and pack ice</li> <li>– Salinity</li> <li>– Energy resources</li> </ul> <p><b>Atmosphere</b></p> <ul style="list-style-type: none"> <li>– Greenhouse effect</li> <li>– Energy resources</li> </ul>	<p><b>Physical properties of solutions</b></p> <ul style="list-style-type: none"> <li>– Concentration (g/L, %, ppm)</li> <li>– pH scale</li> <li>– Ions</li> <li>– Electrical conductivity</li> </ul> <p><b>Chemical changes</b></p> <ul style="list-style-type: none"> <li>– Combustion</li> <li>– Photosynthesis and respiration</li> <li>– Acid-base neutralization reaction</li> <li>– Balancing chemical equations</li> <li>– Law of conservation of mass</li> </ul> <p><b>Organization of matter</b></p> <ul style="list-style-type: none"> <li>– Rutherford-Bohr atomic model</li> <li>– Groups and periods in the periodic table</li> </ul> <p><b>Electricity</b></p> <ul style="list-style-type: none"> <li>– Electrical charge</li> <li>– Static electricity</li> <li>– Ohm’s law</li> <li>– Electrical circuits</li> <li>– Relationship between power and electrical energy</li> </ul> <p><b>Electromagnetism</b></p> <ul style="list-style-type: none"> <li>– Forces of attraction and repulsion</li> <li>– Magnetic field of a live wire</li> </ul>	<p><b>Mechanical engineering</b></p> <ul style="list-style-type: none"> <li>– Characteristics of the linking of mechanical parts</li> <li>– Guiding controls</li> <li>– Construction and characteristics of motion transmission systems (friction gears, pulleys and belt, gear assembly, sprocket wheels and chain, wheel and worm gear)</li> <li>– Speed changes</li> <li>– Construction and characteristics of motion transformation systems (screw gear system, cams, connecting rods, cranks, slides and rotating slider crank mechanisms, rack-and-pinion drive)</li> </ul> <p><b>Electrical engineering</b></p> <ul style="list-style-type: none"> <li>– Power supply</li> <li>– Conduction, insulation and protection</li> <li>– Control</li> <li>– Transformation of energy (electricity and light, heat, vibration, magnetism)</li> </ul> <p><b>Materials</b></p> <ul style="list-style-type: none"> <li>– Constraints</li> <li>– Characteristics of mechanical properties</li> <li>– Types and properties <ul style="list-style-type: none"> <li>- Plastics (thermoplastics, thermosetting plastics)</li> <li>- Ceramics</li> </ul> </li> <li>– Modification of properties (degradation, protection)</li> </ul>

**Compulsory Concepts on Which Students  
May Be Tested in the Applied Science and Technology Examinations (557-410)  
for the 2021-2022 School Year**

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

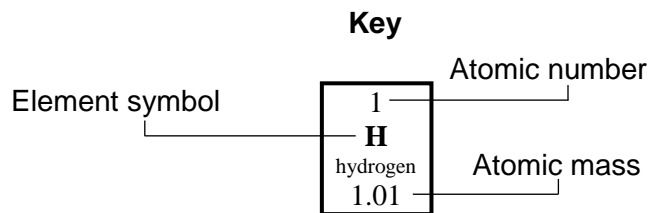
Given the exceptional circumstances, students will not be tested on the concepts of *earth-moon system*, *law of conservation of energy*, *energy efficiency* and *manufacturing* in the 2021-2022 ministerial examinations. This adjustment is intended to ensure consistency with the *Learning to Be Prioritized at the Secondary Level for the 2021-2022 School Year in the Context of the Pandemic*.

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

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

PERIODIC TABLE OF THE ELEMENTS

I A 1												III A 13					IV A 14	V A 15	VI A 16	VII A 17	VIII A 18								
1	1 <b>H</b> hydrogen 1.01											5 <b>B</b> boron 10.81	6 <b>C</b> carbon 12.01	7 <b>N</b> nitrogen 14.01	8 <b>O</b> oxygen 16.00	9 <b>F</b> fluorine 19.00	10 <b>He</b> helium 4.00												
2	3 <b>Li</b> lithium 6.94	4 <b>Be</b> beryllium 9.01											13 <b>Al</b> aluminum 26.98	14 <b>Si</b> silicon 28.09	15 <b>P</b> phosphorus 30.97	16 <b>S</b> sulphur 32.07	17 <b>Cl</b> chlorine 35.45	18 <b>Ar</b> argon 39.95											
3	11 <b>Na</b> sodium 22.99	12 <b>Mg</b> magnesium 24.31	III B 3	IV B 4	V B 5	VI B 6	VII B 7	VIII B 8 9 10			II B 12	19 <b>K</b> potassium 39.10	20 <b>Ca</b> calcium 40.08	21 <b>Sc</b> scandium 44.96	22 <b>Ti</b> titanium 47.90	23 <b>V</b> vanadium 50.94	24 <b>Cr</b> chromium 52.00	25 <b>Mn</b> manganese 54.94	26 <b>Fe</b> iron 55.85	27 <b>Co</b> cobalt 58.93	28 <b>Ni</b> nickel 58.71	29 <b>Cu</b> copper 63.55	30 <b>Zn</b> zinc 65.39	31 <b>Ga</b> gallium 69.72	32 <b>Ge</b> germanium 72.59	33 <b>As</b> arsenic 74.92	34 <b>Se</b> selenium 78.96	35 <b>Br</b> bromine 79.90	36 <b>Kr</b> krypton 83.80
4	37 <b>Rb</b> rubidium 85.47	38 <b>Sr</b> strontium 87.62	39 <b>Y</b> yttrium 88.91	40 <b>Zr</b> zirconium 91.22	41 <b>Nb</b> niobium 92.91	42 <b>Mo</b> molybdenum 95.94	43 <b>Tc</b> technetium 98.91	44 <b>Ru</b> ruthenium 101.07	45 <b>Rh</b> rhodium 102.91	46 <b>Pd</b> palladium 106.40	47 <b>Ag</b> silver 107.87	48 <b>Cd</b> cadmium 112.41	49 <b>In</b> indium 114.82	50 <b>Sn</b> tin 118.71	51 <b>Sb</b> antimony 121.75	52 <b>Te</b> tellurium 127.60	53 <b>I</b> iodine 126.90	54 <b>Xe</b> xenon 131.30											
5	55 <b>Cs</b> caesium 132.91	56 <b>Ba</b> barium 137.33	57-71 lanthanoids	72 <b>Hf</b> hafnium 178.49	73 <b>Ta</b> tantalum 180.95	74 <b>W</b> tungsten 183.85	75 <b>Re</b> rhenium 186.21	76 <b>Os</b> osmium 190.20	77 <b>Ir</b> iridium 192.22	78 <b>Pt</b> platinum 195.09	79 <b>Au</b> gold 196.97	80 <b>Hg</b> mercury 200.59	81 <b>Tl</b> thallium 204.37	82 <b>Pb</b> lead 207.20	83 <b>Bi</b> bismuth 208.98	84 <b>Po</b> polonium (209)	85 <b>At</b> astatine (210)	86 <b>Rn</b> radon (222)											
6	87 <b>Fr</b> francium (223)	88 <b>Ra</b> radium (226)	89-103 actinoids	104 <b>Rf</b> rutherfordium (267)	105 <b>Db</b> dubnium (268)	106 <b>Sg</b> seaborgium (271)	107 <b>Bh</b> bohrium (272)	108 <b>Hs</b> hassium (270)	109 <b>Mt</b> meitnerium (276)	110 <b>Ds</b> darmstadtium (281)	111 <b>Rg</b> roentgenium (280)	112 <b>Cn</b> copernicium (285)	113 <b>Nh</b> nihonium (284)	114 <b>Fl</b> flerovium (289)	115 <b>Mc</b> moscovium (288)	116 <b>Lv</b> livermorium (293)	117 <b>Ts</b> tennessine (292)	118 <b>Og</b> oganesson (294)											
7				57 <b>La</b> lanthanum 138.91	58 <b>Ce</b> cerium 140.12	59 <b>Pr</b> praseodymium 140.91	60 <b>Nd</b> neodymium 144.24	61 <b>Pm</b> promethium (145)	62 <b>Sm</b> samarium 150.36	63 <b>Eu</b> europium 151.96	64 <b>Gd</b> gadolinium 157.25	65 <b>Tb</b> terbium 158.93	66 <b>Dy</b> dysprosium 162.50	67 <b>Ho</b> holmium 164.93	68 <b>Er</b> erbium 167.26	69 <b>Tm</b> thulium 168.93	70 <b>Yb</b> ytterbium 173.05	71 <b>Lu</b> lutetium 174.97											
				89 <b>Ac</b> actinium (227)	90 <b>Th</b> thorium 232.04	91 <b>Pa</b> protactinium 231.04	92 <b>U</b> uranium 238.03	93 <b>Np</b> neptunium (237)	94 <b>Pu</b> plutonium (244)	95 <b>Am</b> americium (243)	96 <b>Cm</b> curium (247)	97 <b>Bk</b> berkelium (247)	98 <b>Cf</b> californium (251)	99 <b>Es</b> einsteinium (252)	100 <b>Fm</b> fermium (257)	101 <b>Md</b> mendelevium (258)	102 <b>No</b> nobelium (259)	103 <b>Lr</b> lawrencium (262)											



## FORMULAS AND QUANTITIES

### Science and Technology

Given the exceptional circumstances, the formula for energy efficiency has been removed from the 2021-2022 ministerial examinations. This adjustment is intended to ensure consistency with the *Learning to Be Prioritized at the Secondary Level for the 2021-2022 School Year in the Context of the Pandemic*.

#### FORMULAS

$$C = \frac{m}{V}$$

C : concentration  
m : quantity of solute  
V : quantity of solution

$$V = R I$$

V : potential difference  
R : resistance  
I : electric current intensity

$$P = V I$$

P : electrical power  
V : potential difference  
I : electric current intensity

$$E = P \Delta t$$

E : energy consumed  
P : electrical power  
 $\Delta t$  : time difference

#### QUANTITIES

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

## FORMULAS AND QUANTITIES

### Applied Science and Technology

Given the exceptional circumstances, the formula for energy efficiency has been removed from the 2021-2022 ministerial examinations. This adjustment is intended to ensure consistency with the *Learning to Be Prioritized at the Secondary Level for the 2021-2022 School Year in the Context of the Pandemic*.

<b>FORMULAS</b>	
$V = RI$ V : potential difference R : resistance I : electric current intensity	$F_g = mg$ $v = \frac{d}{\Delta t}$ F <sub>g</sub> : gravitational force m : mass g : intensity of the gravitational field v : speed d : distance Δt : time difference
$P = VI$ P : electrical power V : potential difference I : electric current intensity	$E = P\Delta t$ E : energy consumed P : electrical power Δt : time difference

<b>QUANTITIES</b>		
NAME	SYMBOL	VALUE
Intensity of the gravitational field on Earth	g	9.8 N/kg
Kilowatt hour	kW•h	1 kW•h = 3 600 000 J





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