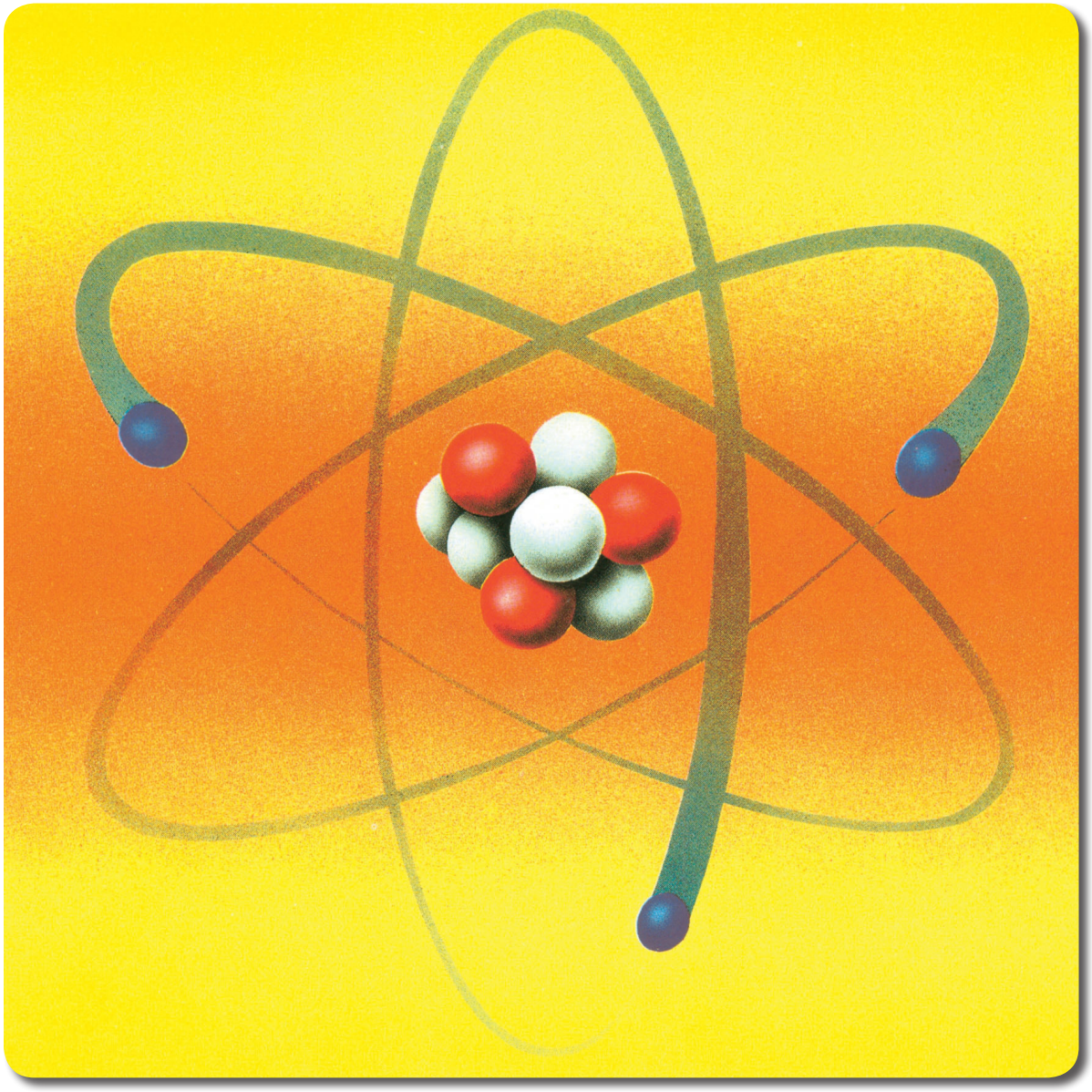
Nuclear Technology: A Matter of Energy

PSC-4010-2
Learning Guide



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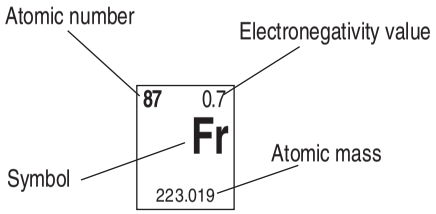
Periodic Table of the Elements



IA	IIA	IIIB	IVB	VB	VIB	VIIB	VIIIB			IB	IIB	IIIA	IVA	VA	VIA	VIIA	VIIIA
1 2.1 H 1.008																	2 He 4.002
3 1.0 Li 6.941	4 1.5 Be 9.012											5 2.0 B 10.811	6 2.5 C 12.011	7 3.0 N 14.007	8 3.5 O 15.999	9 4.0 F 18.998	10 Ne 20.180
11 0.9 Na 22.989	12 1.2 Mg 24.305											13 1.5 Al 26.982	14 1.8 Si 28.086	15 2.1 P 30.974	16 2.5 S 32.066	17 3.0 Cl 35.453	18 Ar 39.948
19 0.8 K 39.098	20 1.0 Ca 40.078	21 1.3 Sc 44.956	22 1.5 Ti 47.88	23 1.6 V 50.942	24 1.6 Cr 51.996	25 1.5 Mn 54.938	26 1.8 Fe 55.847	27 1.8 Co 58.933	28 1.8 Ni 58.693	29 1.9 Cu 63.546	30 1.6 Zn 65.39	31 1.6 Ga 69.723	32 1.8 Ge 72.612	33 2.0 As 74.921	34 2.4 Se 78.96	35 2.8 Br 79.904	36 Kr 83.800
37 0.8 Rb 85.468	38 1.0 Sr 87.62	39 1.3 Y 88.906	40 1.4 Zr 91.224	41 1.6 Nb 92.906	42 1.8 Mo 95.94	43 1.9 Tc 97.907	44 2.2 Ru 101.07	45 2.2 Rh 102.906	46 2.2 Pd 106.42	47 1.9 Ag 107.868	48 1.7 Cd 112.411	49 1.7 In 114.82	50 1.8 Sn 118.710	51 1.9 Sb 121.757	52 2.1 Te 127.60	53 2.5 I 126.904	54 Xe 131.29
55 0.7 Cs 132.905	56 0.9 Ba 137.327		72 1.3 Hf 178.49	73 1.5 Ta 180.948	74 1.7 W 183.85	75 1.9 Re 186.207	76 2.2 Os 190.200	77 2.2 Ir 192.22	78 2.2 Pt 195.080	79 2.4 Au 196.967	80 1.9 Hg 200.59	81 1.8 Tl 204.383	82 1.8 Pb Plomb 207.2	83 1.9 Bi 208.980	84 2.0 Po 208.982	85 2.2 At 209.987	86 Rn 222.018
87 0.7 Fr 223.019	88 0.9 Ra 226.025		104 Unq (261)	105 Unp (262)	106 Unh (263)	107 Uns (262)	108 Uno (265)	109 Une (266)	110 Uun	111 Uuu	112 Uub						

57 1.1 La 138.905	58 1.1 Ce 140.115	59 1.1 Pr 140.907	60 1.1 Nd 144.24	61 1.1 Pm 144.912	62 1.2 Sm 150.36	63 1.2 Eu 151.965	64 1.1 Gd 157.25	65 1.2 Tb 158.925	66 1.2 Dy 162.50	67 1.2 Ho 164.930	68 1.2 Er 167.26	69 1.2 Tm 168.934	70 1.2 Yb 173.04	71 1.2 Lu 174.967
89 1.1 Ac 227.027	90 1.3 Th 232.038	91 1.5 Pa 231.036	92 1.4 U 238.029	93 1.3 Np 237.048	94 1.3 Pu 244.064	95 1.3 Am 243.061	96 1.3 Cm 247.070	97 1.3 Bk 247.070	98 1.3 Cf 251.079	99 1.3 Es 252.083	100 1.3 Fm 257.095	101 1.3 Md 258.098	102 1.3 No 259.100	103 1.3 Lr 260.105

ISBN: 978-2-89493-058-8

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NUCLEAR TECHNOLOGY:
A MATTER OF ENERGY

PSC-4010-2

LEARNING GUIDE

Other courses in the **Physical Science** program:

PSC-4011	*Electricity: What's the Connection?*
SCP-4012	*Ionic Phenomena: A Study of an Environmental Problem*

NUCLEAR TECHNOLOGY: A MATTER OF ENERGY

Project coordinator:	Alain Pednault
Production Coordinator (Previous Editions):	Jean-Simon Labrecque
Production Coordinator at the DDFD:	Mireille Moisan
Production Coordinator at the DFGA:	Pauline Pelletier
Program Coordinator at the DFGA:	Serge Leloup Pierrette Marcotte
Author:	René Vézina
Updated Version:	Danielle Ouellet
Illustrations:	Jean-Philippe Morin
Content Revisor:	Céline Tremblay
Layout:	Daniel Rémy
Layout (Previous Editions):	Mark Malin
Translation:	Ministère de l'Éducation Direction de la production en langue anglaise Services à la communauté anglophone
First edition:	September 1997

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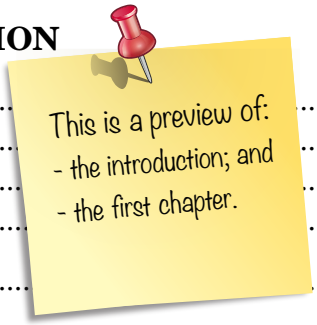
March 2012

Legal Deposit - 1997
Bibliothèque nationale du Québec
National Library of Canada
ISBN 978-2-89493-058-8

TABLE OF CONTENTS



Chapter 2: An Evolving Model

Chapter 3: The Classification of Matter

Chapter 4: Changes in Matter

Chapter 5: The Different Uses of Nuclear Energy

Chapter 6: Issues relating to Nuclear Technology

Chapter 7: What Do You Think?

CONCLUSION

GENERAL INTRODUCTION

OVERVIEW

The Physical Science Program

Welcome to the module entitled *Nuclear Technology: A Matter of Energy*, which is part of the Secondary IV Physical Science program. This program includes two additional modules: *Electricity: What's the Connection?* and *Ionic Phenomena: A Study of an Environmental Problem*.

This science program was designed to help you learn the fundamentals of physics and chemistry. This basic knowledge will give you a better understanding of the social and technological realities of modern society, thereby helping you to become an informed citizen. This course also allows you to develop an interest in science and research and prepares you for optional Secondary V programs.

Nuclear Technology: A Matter of Energy

The module entitled *Nuclear Technology: A Matter of Energy* is a learning guide designed to meet all the requirements of a Secondary IV course. If you meet meet all the certification requirements described in the section entitled **Information for Distance Education Students**, you will earn two credits for this course, whose identification code is PSC-4010.

This module covers the major scientific principles pertaining to the fundamental relationship between matter and energy. In addition, you will learn about the development of the knowledge that made it possible to harness nuclear energy as well as the various military and socioeconomic applications of nuclear technology. This course also encourages debate on the social issues relating to the use of nuclear energy.

OBJECTIVES

Chapter 1: Defining the Debate

Chapter 2: An Evolving Model

Terminal Objectives	Intermediate Objectives
Compare the current simplified atomic model with the atomic theories developed by the Ancient Greeks and by Dalton, Thomson, Rutherford and Bohr.	**State** the atomic theory of the following Ancient Greek philosophers: Leucippus, Democritus, Aristotle and Empedocles. **State** the basic principles behind Dalton's atomic theory. **Describe** Thomson's atomic model. **Describe** Rutherford's atomic model. **Describe** Bohr's atomic model. **Describe** the current simplified atomic model.
Put the different atomic theories in a historical and technical context.	**Identify** the historic discovery or event that marked the passage from one atomic model to another.

Chapter 3: The Classification of Matter

Terminal Objectives	Intermediate Objectives
In the modern periodic table, **locate** the metals, the nonmetals, hydrogen and the actinides as well as the following chemical families: the alkali metals, the alkaline earth metals, the halogens and the noble gases.	**Define** the expression "chemical family" or "group" as it pertains to the periodic table. **Define** the term "period" as it pertains to the periodic table. **Determine** the position of the metals and the nonmetals in the periodic table. **Give** the characteristics and the position in the periodic table of the following elements: hydrogen, the alkali metals, the alkaline earth metals, the halogens, the noble gases, the transition metals and the actinides.

Given the name of one of the first twenty elements, **provide** information about that element which can be found in or deduced from the modern periodic table.	**Match** each of the first twenty elements in the periodic table with its chemical symbol. **State** the relationship between the atomic number of an element and the number of protons and electrons in its atoms. **State** the relationship between the atomic number of an element and its mass number. **Apply** the relationship between the number of protons, neutrons and electrons in an atom and the atomic number and mass number of that element. **State** the relationship between the group number and the number of electrons in the outermost energy level. **State** the relationship between the period number and the number of energy levels.
Compare the atomic structure of the isotopes of an element.	**Define** the term "isotope." **State** the number of protons, neutrons and electrons in the isotopes of an element.
Calculate the atomic mass of an element, given the relative abundance of its isotopes.	**Distinguish** between the mass number and the atomic mass of an element. **Define** the term "relative abundance."

Chapter 4: Changes in Matter

Terminal Objectives	Intermediate Objectives
Classify examples of changes in matter as physical, chemical or nuclear changes.	**Give** examples of changes in matter. **Identify** the characteristics of a physical change.

Identify the characteristics of a chemical change.

Identify the characteristics of a nuclear change.

Distinguish among the following types of nuclear reactions: radioactivity, fission, fusion.

Briefly **describe** radioactivity.

Distinguish between natural radioactivity and artificial radioactivity.

Briefly **describe** nuclear fission.

Briefly **describe** a chain reaction.

Briefly **describe** nuclear fusion.

Compare the nature, speed, electric charge and penetrating power of alpha, beta and gamma radiation and of X-rays and **describe** how these different types of radiation affect matter.

Distinguish between the electron configuration of a neutral atom and that of its corresponding ion.

Distinguish between a positive ion and a negative ion.

Indicate the part of the atom where radioactive decay occurs.

Describe the different types of radiation emitted when radioactive elements decay.

Distinguish between X-rays and gamma rays.

Distinguish between wave radiation and particle radiation.

Describe how alpha, beta, gamma and X-rays affect an atom.

Recognize the different types of ionizing radiation.

Given the half-life of a radioactive element, **calculate** how much of a given sample of that element will remain after a certain period of time or the time required for a certain amount of that element to decay.	**Define** the expression "half-life." **State** the relationship between the half-life of a radioactive element and the amount of a given sample of that element which remains after a certain period of time.
For a given decay process, **identify** the radioactive element, the type of radiation emitted or the new element obtained.	**Give** the atomic notation for the alpha or beta radiation emitted during a decay process. **Write** the nuclear equation for the decay of a radioactive element that emits alpha or beta radiation. **Verify** that the law of conservation of matter applies for a given alpha or beta decay process.
State the relationships between the energy released during a nuclear reaction, the mass defect and the stability of the resulting isotope.	**Define** "mass defect". **Explain** how the stability of an atom relates to the number of neutrons in its nucleus. **State** the relationship between the mass of a given quantity of matter and the energy it can release.

Chapter 5: The Different Uses of Nuclear Energy

Terminal Objectives	Intermediate Objectives
Compare the atomic bomb and the hydrogen bomb in terms of their components, their power, the type of nuclear reaction involved and their destructive effects.	Briefly **describe** the structure and operation of an atomic bomb (A-bomb). **State** the nuclear reactions involved in detonating an atomic bomb (A-bomb). Briefly **describe** the structure and operation of a hydrogen bomb (H-bomb).

	State the nuclear reactions involved in detonating a hydrogen bomb (H-bomb).
Compare the operation of a hydroelectric power station, a conventional thermal power station and a nuclear power station.	**Describe** how a power station works in general. Briefly **describe** how a hydroelectric power station works. Briefly **describe** how a conventional thermal power station works. Briefly **describe** how a nuclear power station works.
Describe the operation of a CANDU nuclear reactor.	**Describe** the function of the main components of a CANDU nuclear reactor.
Compare the technology used in CANDU nuclear reactors with the technology used in other countries (former USSR, England, United States).	**Identify** the characteristics of Russian, English and American nuclear power stations. Briefly **describe** what a Slowpoke reactor is.
Describe the use of radioactive elements in medicine, food irradiation and carbon-14 dating.	**Determine** the function of the radioactive isotopes used in medicine. **Identify** the advantages of irradiating food and surgical instruments. **Distinguish** between radioactivity and irradiation. **State** the significance of the relationship between the amount of carbon-14 and the amount of carbon-12 found in a sample to be dated.
Compare the advantages, disadvantages and difficulties involved in using nuclear fission and nuclear fusion to produce electricity.	**List** the advantages and disadvantages of using nuclear fission to produce electricity. **State** the characteristics of plasma.

	List the advantages and difficulties involved in using nuclear fusion to produce electricity.

Chapter 6: Issues relating to Nuclear Technology

Terminal Objectives	Intermediate Objectives
Match each unit of measure for radiation with the phenomenon it measures.	**Define** the following units of measure: the curie and the becquerel.
	Define the following units of measure: the rad and the gray.
	Define the following units of measure: the rem and the sievert.
Describe the risks, consequences and advantages of using nuclear energy.	**Compare** the extent to which we are exposed to the main sources of natural and artificial radiation.
	List the risks involved in mining, processing and using uranium ore.
	Identify the risks associated with the normal or faulty operation of a nuclear power station and with the disposal of its waste.
	Identify the risks associated with the military use of nuclear energy.
	Describe how the use of nuclear technology affects public health, the environment and democracy.
	Describe how nuclear technology benefits the economy and the environment, as well as scientific and technological research and development in Canada.

Chapter 7: What Do You Think?

Terminal Objectives	Intermediate Objectives
Express one's point of view regarding a specific use of nuclear technology, ensuring that the reasoning used to support this opinion is based on facts.	**Distinguish** between such things as facts, opinions, and value judgements. In newspaper and magazine articles, **identify** facts, opinions and value judgements relating to the risks, consequences and advantages involved in using nuclear technology.

HOW TO USE THIS LEARNING GUIDE

This course applies the main principles of individualized learning, which encourages you to:

- take an active part in the learning process,
- take responsibility for your own progress,
- work at your own pace,
- put your own knowledge and experience to use.

As you work through this course at your own pace, you will be able to identify your strengths and weaknesses, discover the reasons for any problems you may have and decide what steps you must take to resolve these problems so you can continue to make progress.

Throughout this course, you will be able to consult your teacher if you are experiencing any difficulty. He or she will provide you with advice, encouragement, and constructive comments and feedback, adapting these services to meet your specific needs.

This learning guide is divided into three parts: the general introduction, the learning activities and the conclusion.

Part I provides a general introduction to the course, outlining its objectives and providing the information you will need to get started. It also includes a section entitled **Prerequisites**, which deals with the different concepts you should be familiar with before beginning this course.

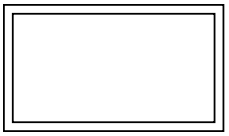
Part II consists of the learning activities, which have been divided into seven chapters. Each chapter covers a certain number of themes using explanations, tables, illustrations, exercises and, if necessary, activities and experiments. Each chapter begins with a list of objectives and ends with a list of key words, a summary and review exercises that will help you go over what you have learned.

The last two chapters provide a wealth of information on social issues. By reading the related articles found in the appendices (the coloured pages at the end of this guide), you will develop an understanding of the situations and issues covered by the media.

This guide is organized in such a way that you must work through it chapter by chapter. The questions and exercises will help you evaluate your knowledge as you go along. Throughout this guide, you will encounter different symbols and typefaces, which are explained below.

Bold Words mentioned for the first time are printed in bold and defined. In some cases, the initial definition is expanded on lateo and a more formal definition is given in the "Terminology" section at the end of this guide. Most of these words are also found in the list of key words at the end of each chapter and in a special supplement where you must write your own definition of these terms.

 A light bulb indicates additional information: this information is not part of the course as such and need not be memorized.

 A box highlights important information that you should keep in mind.

 A hand signals an "Activity." In these cases, guided questions are used to help you better understand different situations or account for different phenomena.

 A flask signals an "Experiment." In these cases, guided questions and simple tests are used to help you better understand different situations or account for different phenomena.

* Questions marked with an asterisk are optional.

The conclusion in Part III summarizes what you have learned and includes an optional crossword puzzle to test your knowledge of scientific vocabulary as well as a compulsory self-evaluation test. The self-evaluation test should help you determine whether you have mastered the subject matter of this course and are therefore able to write the final examination. The conclusion also includes an answer key for the self-evaluation test, for the exercises in each chapter and for the activities, experiments and review exercises. A bibliography of works used to produce this learning guide completes Part III. You may wish to consult these books and publications for further information on the topics covered in this course.

Finally, the appendices printed on coloured pages are found at the back of this guide. They consist of different newspaper and magazine articles that you will be asked to read when working on Chapters 6 and 7.

Good luck!

INFORMATION FOR DISTANCE EDUCATION STUDENTS

This guide is the main work tool for this course and tries to meet the specific needs of adult students taking distance education courses. Distance education is a flexible system with several advantages, one of which is the opportunity to work at your own pace in the comfort of your own home. This system does, however, involve certain challenges: you have to take responsibility for your own learning and motivate yourself to work at a steady pace. Here are some tips that will help you in your work.

Work Pace

- Draw up a study timetable that takes into account your personality and needs as well as your family, work and other obligations.
- Try to study a few hours per week. You should break up your study time into several one- or two-hour sessions.
- Do your best to stick to your study timetable.

Materials

In addition to your learning guide, have all the materials you need close at hand:

– a pencil to write your answers,
– an eraser,
– a coloured pen for corrections,
– a light-coloured marker to highlight important information,
– a dictionary,
– a pad of paper.

Learning Activities

Each chapter in this guide contains an explanation of the theory, as well as practical activities consisting of exercises with their corresponding answer keys. You will also find a number of experiments involving simple tests that can be carried out with readily-available materials. It is important to take the time to conduct these experiments properly in order to develop the skills required for the laboratory work you will do if you take other science courses.

Start by skimming through each part of this guide to become familiar with the content and the main headings.

Read the theory carefully:

- Highlight the important points.
- Take notes in the margins.
- Look up new words in the dictionary.
- Summarize important passages in your own words.
- In the supplement entitled **Key Words in Each Chapter**, write your own definition of the terms that appear in bold type.
- Study the diagrams carefully.
- Write down questions relating to ideas you don't understand.

Exercises

The exercises come with an answer key that begins on page C.31 of this guide.

- Do all the exercises.
- Read the instructions and questions carefully before writing your answer.
- Do all the exercises to the best of your ability without looking at the answer key. Reread the questions and your answers and revise your answers, if necessary. Then check your answers against the answer key and try to understand any mistakes you made.
- Complete a chapter before doing its review exercises. Doing these exercises without referring to the lesson you have just completed is a better way of preparing for the final examination.

Your Tutor

Your tutor is the person who will give you any help you need throughout this course. He or she will answer your questions and correct and comment on your homework assignments. The letter included with this guide or that you will receive shortly tells you when and how to contact your tutor.

Don't hesitate to call your tutor if you are having difficulty with the theory or the exercises, or if you need some words of encouragement to help you get through this course. Write out your questions and get in touch with your tutor at the times indicated in the letter mentioned above. If necessary, write to him or her.

Your tutor will guide you in your work and provide you with the advice, constructive criticism and support that will help you succeed in this course.

Homework Assignments

In this course, you will have to do three homework assignments: the first after completing chapters 1, 2 and 3, the second after completing chapter 4 and the third after completing chapters 5, 6 and 7. In addition, the final homework assignment may contain questions covering the entire course. It is important that you not send in a homework assignment until you have received the corrections for the previous one.

These assignments will show your tutor whether you understand the subject matter and are ready to go on to the next chapter in the course. If your tutor feels you are not ready to move on, he or she will indicate this on your homework assignment, providing comments and suggestions to help you get back on the right track. It is important to read these corrections and comments carefully.

You must obtain an average of at least 60% on the three homework assignments to be entitled to write the examination that permits you to earn credits for this course. The homework assignments are similar to the examination. Since the exam will be supervised and you will not be able to use your notes, the best way to prepare for it is to do your homework assignments without referring to your learning guide and to take note of your tutor's corrections so that you can make any necessary adjustments.

Remember not to send in the next assignment until you have received the corrections for the previous one.

Research Paper

The research paper is an integral part of this course and is the first part of the final examination. The suggested topics, the description of the work to be done and the marking scale are outlined in the candidate's booklet, which will be mailed to you shortly if you haven't already received it. Read this booklet as soon as possible and keep this project in mind throughout the course.

- Choose your topic as soon as possible.
- Collect newspaper and magazine articles related to your topic.

- Read the sections entitled "Distinguishing a Fact from an Opinion" and "The Different Parts of a Research Paper" in **Prerequistes**.
- Take notes for your paper throughout this course.

Certification

If you obtain an average of at least 60% on your homework assignments, you may write the examination that permits you to earn credits for this course. The examination is divided into two separate parts.

In Part I, you must write a 400-word research paper in which you take a position on a particular topic (for or against). This part of the examination is worth 25% of your final mark and tests your ability to express an opinion based on facts.

Part II is worth 75% of your final mark and is written in one two-hour session. It consists of short-answer and multiple-choice questions that test your ability to understand and analyze information. This part of the examination is supervised and you are not permitted to use your class notes, but you will be provided with a periodic table that does not include the names of the elements.

To earn credits for this course, you must obtain a total mark of at least 60% for both parts of the examination. Your homework assignments will not count towards your final mark.

Useful Information

Number of Credits:	2 credits at the Secondary IV level
Course Duration:	Approximately 50 hours of study
Number of Homework Assignments:	3
Opportunity to Revise and Re-submit Homework Assignments:	None
Pass Mark:	Average of 60% on the homework assignments Average of 60 % for both parts of the examination

PREREQUISITES

Scientific Notation

With scientific notation, we can express very large or very small numbers without using a long, cumbersome series of digits.

Let's first review the notation for different powers of 10.

10 000	$= 10 \times 10 \times 10 \times 10$		$= 10^4$
1 000	$= 10 \times 10 \times 10$		$= 10^3$
100	$= 10 \times 10$		$= 10^2$
10	$= 10$		$= 10^1$
1	$= 1$		$= 10^0$
0.1	$= 1/10$	$= 1/10^1$	$= 10^{-1}$
0.01	$= 1/100$	$= 1/10^2$	$= 10^{-2}$
0.001	$= 1/1\,000$	$= 1/10^3$	$= 10^{-3}$
0.000 1	$= 1/10\,000$	$= 1/10^4$	$= 10^{-4}$

Any given number can be expressed in several ways. For example, the number 4 560 can be written as follows:

$4\,560 = 4\,560 \times 1$	$= 4\,560 \times 10^0$
$4\,560 = 456 \times 10$	$= 456 \times 10^1$
$4\,560 = 45.6 \times 100$	$= 45.6 \times 10^2$
$4\,560 = 4.56 \times 1\,000$	$= 4.56 \times 10^3$
$4\,560 = 0.456 \times 10\,000$	$= 0.456 \times 10^4$

Scientific notation involves expressing a number as a power of 10 multiplied by a number greater than or equal to 1 and less than 10. In the example above, 4 560 can be written as 4.56×10^3 in scientific notation.

Example

The following numbers are written in scientific notation.

$740 = 7.40 \times 10^2$
$0.5 = 5 \times 10^{-1}$
$13\,400\,000 = 1.34 \times 10^7$
$0.000\,467 = 4.67 \times 10^{-4}$
$1\,994 = 1.994 \times 10^3$
$53.004 = 5.300\,4 \times 10^1$

The Metric System

Common SI Units

Quantity	Unit	Symbol
Heat and Energy	joule	J
Electric charge	coulomb	C
Electric current	ampere	A
Force	newton	N
Frequency	hertz	Hz
Luminous intensity	candela	cd
Length	metre	m
Mass	kilogram	kg
Pressure	pascal	Pa
Power	watt	W
Amount of substance	mole	mol
Resistance	ohm	Ω
Temperature	kelvin or Celsius	K or °C
Time	second	s
Voltage	volt	V
Volume	litre	L

Multiples and Submultiples of SI Units

Prefix	Symbol		Multiplier
Exa	E	10^{18} =	1 000 000 000 000 000 000
Peta	P	10^{15} =	1 000 000 000 000 000
Tera	T	10^{12} =	1 000 000 000 000
Giga	G	10^{9} =	1 000 000 000
Mega	M	10^{6} =	1 000 000
Kilo	k	10^{3} =	1 000
Hecto	h	10^{2} =	100
Deca	da	10^{1} =	10
Deci	d	10^{-1} =	0.1
Centi	c	10^{-2} =	0.01
Milli	m	10^{-3} =	0.001
Micro	μ	10^{-6} =	0.000 001
Nano	n	10^{-9} =	0.000 000 001
Pico	p	10^{-12} =	0.000 000 000 001
Femto	f	10^{-15} =	0.000 000 000 000 001
Atto	a	10^{-18} =	0.000 000 000 000 000 001

Examples

7 km = 7 kilometres = 7 000 metres = 7 000 m

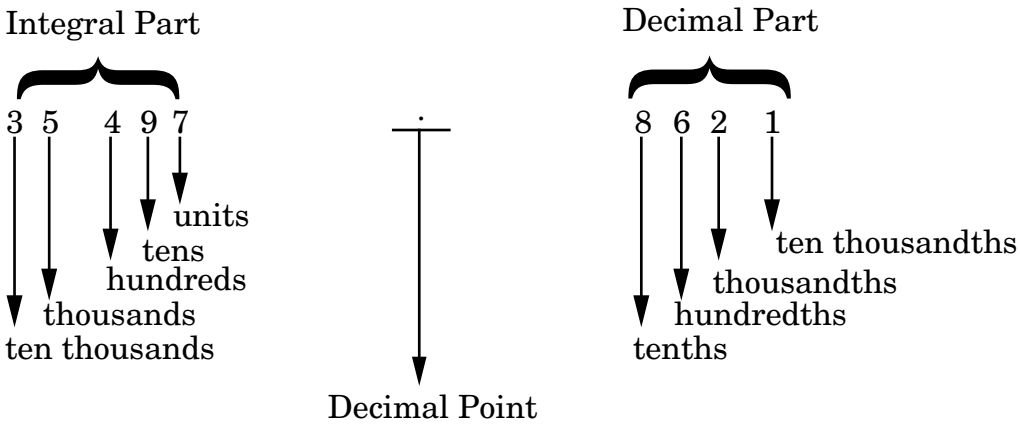
8 hL = 8 hectolitres = 800 litres = 800 L

9 g = 9 grams = 0.009 kilogram = 0.009 kg

How to Round off a Number

There are different reasons for rounding off a number to the nearest unit, to the nearest tenth or to any other place value. To begin with, let's look at the names of the positions occupied by the digits in a decimal number. For example, take the number 35 497.862 1. The place values of its digits read as follows:

Decimal Number 35 497.862 1



To round off this number to any place value, use the following procedure:

- Identify the digit occupying the position corresponding to the required degree of accuracy.
- Identify the first digit to the right of the designated position:
  - if it is 0, 1, 2, 3 or 4, then the digit in the designated position remains the same;
  - if it is 5, 6, 7, 8 or 9, then the digit in the designated position should be increased by 1.
- All the digits to the right of the designated position:
  - become zero if they are in the integral part of the number;
  - disappear if they are in the decimal part of the number.

Example
Round off the number 35 497.862 1 to the nearest unit, to the nearest tenth and to the nearest hundredth.

- To the nearest unit
  The digit 7 is in the unit's place. The first digit to the right of 7 is 8; therefore, 7 (in the unit's place) is increased by 1 and becomes 8. All the other digits to the right of the unit's place disappear. The result is 35 498.
- To the nearest tenth
  The digit 8 is in the first decimal place (the tenths). The first digit to the right of 8 is 6; therefore, 8 is increased by 1 and becomes 9. All the other digits to the right of the unit's place disappear. The result is 35 497.9.
- To the nearest hundredth
  The digit 6 is in the second decimal place (the hundredths). The first digit to the right of 6 is 2; therefore, 6 does not change. All the other digits to the right of the unit's place disappear. The result is 35 497.86.

An Important Property of Proportions

In any proportion, the product of the extremes is equal to the product of the means.

Since a proportion consists of two equal ratios, we can say that $\frac{1}{2} = \frac{4}{8}$. In this case, if 1 and 8 are the extremes, and 2 and 4 are the means, then $1 \times 8 = 2 \times 4$.

Using this property, we can determine an unknown value if we know the other three values in the proportion.

Example
If you travel an average of 50 kilometres on 6 litres of gas, how many litres will you need to travel 325 kilometres under the same conditions?

If 50 km correspond to 6 L, then
325 km correspond to ? L.

We can now state the following proportion:

$$\frac{50 \text{ km}}{325 \text{ km}} = \frac{6 \text{ L}}{x}$$

$50 \text{ km} \times x = 325 \text{ km} \times 6 \text{ L}$ by applying the property of proportions

$$x = \frac{325 \cancel{\text{km}} \times 6 \text{ L}}{50 \cancel{\text{km}}}$$ by solving the equation

$$x = 39 \text{ L}$$

The Law of Electric Charges

For the purposes of this course, the law of charges can be summarized as follows.

There are two types of electric charges: positive charges (represented by a + sign) and negative charges (represented by a – sign). Like charges (+ and + or – and –) repel each other, whereas opposite charges (+ and –) attract each other. For example, a negatively charged electron and a positively charged proton attract each other. However, two electrons or two protons will tend to repel each other.

Any uncharged, or neutral, object contains an equal number of positive charges and negative charges.

The Laws of Exponents

We can multiply several powers of a given number by adding their exponents.

E.g., $10^3 \times 10^2 = 10 \times 10 \times 10 \times 10 \times 10 = 100\,000 = 10^5$
or
$10^3 \times 10^2 = 10^{3+2} = 10^5$

We can divide several powers of a given number by subtracting their exponents.

E.g., $\frac{10^4}{10^2} = \frac{\cancel{10} \times \cancel{10} \times 10 \times 10}{\cancel{10} \times \cancel{10}} = 100 = 10^2$ or

$$\frac{10^4}{10^2} = 10^{4-2} = 10^2$$

Note: $0.001 = \frac{1}{1\,000} = \frac{1}{10^3} = 10^{-3}$

$10^1 = 10$ and $10^0 = 1$

Example

Perform the following operation: $\frac{8.4 \times 10^7}{4 \times 10^3}$.

If we apply the law of exponents for numbers with the same base, the result is as follows:

$$\frac{8.4 \times 10^7}{4 \times 10^3} = \frac{8.4}{4} \times 10^{7-3} = 2.1 \times 10^4$$

These operations can be performed using a calculator; refer to the operating instructions.

Distinguishing a Fact from an Opinion

What is the difference between a fact and an opinion? Newspapers, magazines, radio and television constantly bombard us with all sorts of information. Sometimes we get the facts and sometimes certain people give their opinions, but the distinction between the two is not always clearly stated. People who have strong beliefs will often try to present their opinion as a proven fact.

Let's first define the terms we wish to understand. The best way to do this is to consult the dictionary.

Fact
- A thing done, something that has actual existence. (*Webster's Third New International Dictionary*)
- Something that has really occurred or is actually the case. (*The Oxford English Dictionary*)

Opinion
- A view, judgment or appraisal formed in the mind about a particular matter. (*Webster's Third New International Dictionary*)
- What one thinks of a person or thing. (*The Oxford English Dictionary*)

We therefore state a fact and express an opinion.

Examples

Facts

- The Earth is round.
- The personal computer has become very popular over the last few years.
- The stock market crashed in October 1987.
- France is a country located in western Europe.
- When it dropped the atomic bomb on Japan in 1945, the United States became the first country to use nuclear weapons against civilians.

Opinions

- It seems to me that the arms race has lasted long enough.
- I'm convinced that the Montreal Canadiens are the world's best hockey team.
- I think Québec will be better off if it remains part of Canada.
- I don't think the weather will be nice tomorrow.
- The discovery of nuclear energy was a good thing for humanity.

The Different Parts of a Research Paper

Introduction

The introduction consists of two paragraphs. In the first paragraph, you present your topic by explaining what you are going to talk about. You must use key words and mention important data or information that will indicate the kind of problem you will be dealing with. It is important to clearly define your topic, since this will determine your reader's understanding of what you have to say. The first paragraph should take up **six to eight lines**.

In the second paragraph of the introduction, you state your position, or opinion, on the topic you are examining. You must answer the following question: "Are you in favour of this event, this measure or this situation?" You must clearly express your point of view in complete sentences, which will involve re-explaining your topic. This should take up **two to three lines**.

Body

Start the body of the paper by presenting four arguments that support your position. Each reason you give for your position on the topic is an argument in your favour. You can use an example or a fact to strengthen your argument. This is a highly effective method of convincing your reader. Write **four to six lines per argument**.

You must then present and disprove two arguments expressed by those opposed to your position. Write **three to six lines per argument**.

Each argument that could be put forward by those opposed to your opinion is an argument against your position. Be careful about how you incorporate your opponents' arguments into your paper. Use expressions like "Some believe that..." or "Some people say that..." or any other phrase indicating that you do not necessarily agree with these ideas.

Any argument against your position must obviously be refuted or countered. If you mention an opponents' arguments without refuting them, this will mean that you agree with them. The purpose of this project is not to side with an opponent, but rather to show that you are right. Finding a counterargument is an excellent way of weakening an opponent's argument. Your ability to do this will make your point of view more credible.

Conclusion

You have explained your topic, stated your position on this topic, presented your arguments and refuted your opponents' arguments. In short, the paper clearly shows that yours is the most reasonable opinion. In the conclusion, you can reassert your position. At this point, you should open up the discussion. For instance, you could touch on another aspect of your topic that would be worthwhile examining, or you could mention a subject related to your research topic by showing the connection between the two. The conclusion should take up **five to six lines**.

The number of lines indicated for each part of the paper is simply meant as a rough guide.

Useful Tips

Here are a number of useful tips on writing your research paper.

- Analyze your chosen topic carefully. Think about its different aspects: write down your ideas as they come to mind.
- Prepare a work plan in which you outline your ideas as follows:

Introduction	
Body	Arguments for
	Arguments against
Conclusion	

- Write a double-spaced first draft so that you can reread and correct your work, and cross out or add information. Use a dictionary or grammar book if necessary.
- Refer to the marking scale and see if your first draft meets these standards.
- Prepare a clean copy of your work.

NUCLEAR TECHNOLOGY: A MATTER OF ENERGY

Human beings have been studying the concept of the atom since the time of the Ancient Greeks, but scientists did not really succeed in unravelling the mysteries of matter until the turn of the twentieth century.

What are the forces that lie within matter? How does it evolve? How can we influence the changes that take place at the very heart of the atom?

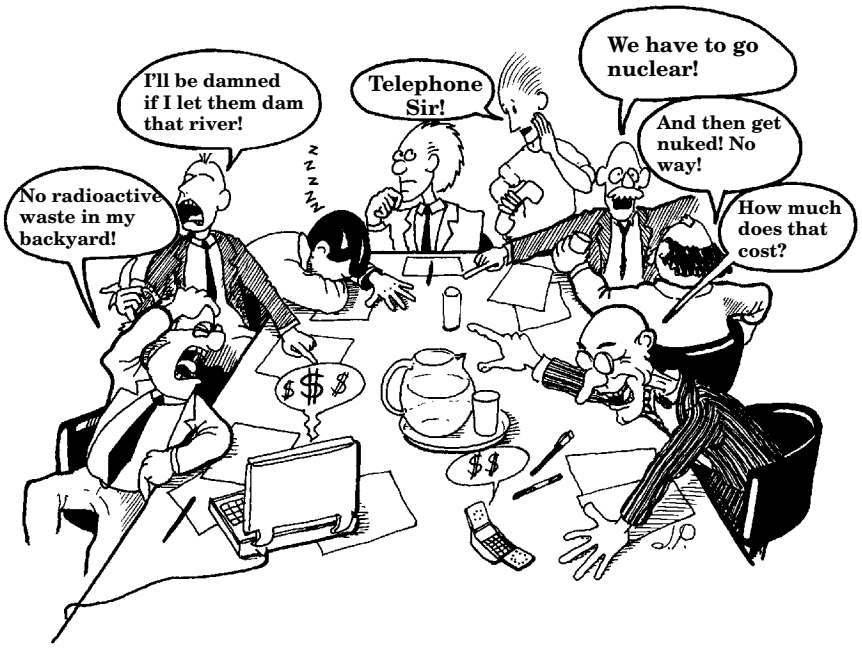
These basic questions will be examined in this course. You will begin by studying the major scientific principles pertaining to the fundamental relationship between matter and energy. Our increased knowledge has allowed us to harness nuclear energy, the most powerful form of energy ever generated. This course also looks at how modern society has used the energy in the nucleus of the atom for military and peaceful purposes.

These developments have had significant repercussions, and many of these developments remain controversial. How should society regard the technology derived from scientific progress? The latter part of the course will focus on this fundamental question. You will examine the ins and outs of this issue with a view to developing your own informed opinion about one of the major challenges of this century.

To understand the current debate, you have to know the basic principles of science and be able to relate them to the things that matter in our daily lives. This connection between science and everyday concerns is a recurring theme in this course.

Chapter 1

Defining the Debate



1.1

The media covers energy issues every day. Topics that regularly make the headlines include energy use in the twenty-first century, nuclear energy, electricity production and consumption, Hydro-Québec's role and installations and megaprojects such as the proposed Great Whale power station.

A golden opportunity: hydrogen can make Canada an energy powerhouse
The Globe and Mail, *Toronto,* 1988 02 25

The Great Debate: Do we need nuclear energy?
Winnipeg Free Press, 1996 12 29

Efficiency to go: Hydro-Québec goes door-to-door delivering energy saving devices
The Gazette, Montreal, 1993 12 08

Québec must opt for nuclear energy
La Presse, Montréal, 1989 09 16

Environment key issue in Great Whale delay: N.Y.
The Gazette, Montreal, 1991 08 29

Converting to electricity: the end of an era
Do Quebecers waste hydroelectric power?
La Presse, Montréal, 1989 09 16

More than half of Quebecers in favour of Great Whale
Le Soleil, Quebec City, 1991 09 16

a) Briefly define the term "energy" in your own words.

_____

_____

_____

b) Look up the dictionary definitions of the term "energy" and copy out those relating to physical science.

_____

_____

_____

Look around you. Everything you see and do depends on energy. Every morning you wake up to a world full of energy: your radio, water heater, toaster and kettle all work because they are supplied with the energy they need. Without energy, there would be no cars and buses to take us from place to place. Even our body needs the energy it gets from food! Without energy, nothing works. It is so much a part of our daily life that we sometimes forget how precious it is.

ENERGY: A MEASURABLE PHENOMENON

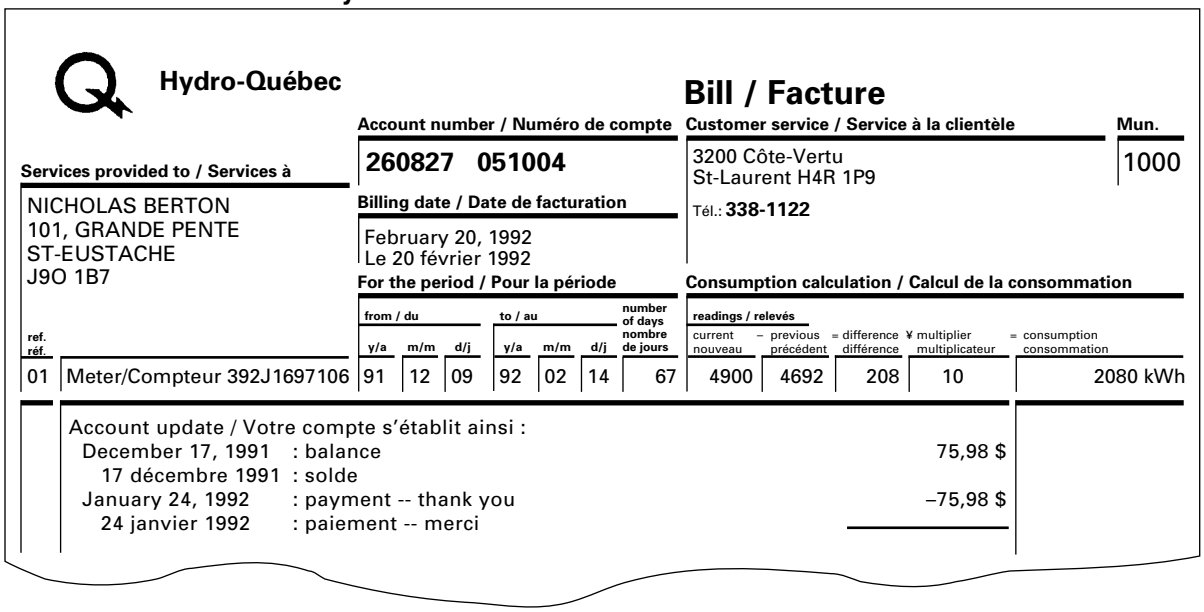
What exactly is energy? The concept of energy refers to many physical phenomena. It is often related to strength. People will say "I have no energy today" because they feel a bit weak. The word "energy" always suggests the idea of work, whether we are talking about the piston engine of a car, the heating system in a house or the food that keeps us alive. In short, **energy** is the ability to do work.[1]

We can measure the ability to do work and give it a value. In science, the unit of measurement commonly used for energy is the **joule** (J).

Although you may not realize it, you are already familiar with other units of energy from reading your electricity bill or the information on food packaging. You probably know that electric energy is measured in **kilowatt-hours** (kWh) and that food energy is measured in calories. Let's look at these two units more closely.

1. This definition of energy is found in physics textbooks, but the term "work" does not have the same meaning in physics as it does in everyday language. Nevertheless, to understand the topics in this guide, you need only remember that there is a difference without knowing the nature of this difference.

Figure 1.1
Electricity Bill



Hydro-Québec

Bill / Facture

Services provided to / Services à

NICHOLAS BERTON
101, GRANDE PENTE
ST-EUSTACHE
J9O 1B7

Account number / Numéro de compte
260827 051004

Billing date / Date de facturation
February 20, 1992
Le 20 février 1992

Customer service / Service à la clientèle
3200 Côte-Vertu
St-Laurent H4R 1P9
Tél.: **338-1122**

Mun.
1000

For the period / Pour la période

Consumption calculation / Calcul de la consommation

ref. réf.		from / du y/a	m/m	d/j	to / au y/a	m/m	d/j	number of days nombre de jours	readings / relevés current nouveau	– previous précédent	= difference différence	¥ multiplier multiplicateur	= consumption consommation
01	Meter/Compteur 392J1697106	91	12	09	92	02	14	67	4900	4692	208	10	2080 kWh

Account update / Votre compte s'établit ainsi :

December 17, 1991	: balance	75,98 $
17 décembre 1991	: solde	
January 24, 1992	: payment -- thank you	–75,98 $
24 janvier 1992	: paiement -- merci	

The electricity bill above shows that this person used 2 080 kWh of energy over a 67-day period.

Your total electricity bill depends on the amount of electricity used. Hydro-Québec calculates this cost by multiplying the number of kilowatt-hours by the price per kilowatt-hour.

The joule and the kilowatt-hour are the two units generally used to measure energy. You are most probably familiar with another unit of energy that has gradually gone out of use since the advent of the International System of Units. It terrifies those trying to lose weight and appears on food product labels.

Of course, this description refers to the calorie, a term derived from the Latin word *calor* meaning "heat." Heat is a form of energy. When we exercise and work up a sweat, we often say that we are burning calories. However, what if we simply stored all these calories? Calories are a measure of the food energy we need to live. There are two types of calories: large calories, denoted by Cal, and small calories, denoted by cal. A large calorie equals a thousand small calories (1 Cal = 1 000 cal). There is also a relationship between a joule and a calorie: one small calorie equals 4.18 joules. Most often, an adult woman needs 2000 calories per day and an adult male, 2500 calories.

Petroleum: A Basic Unit of Energy

The unit commonly used to measure the total energy consumption of a country or province is the tep.

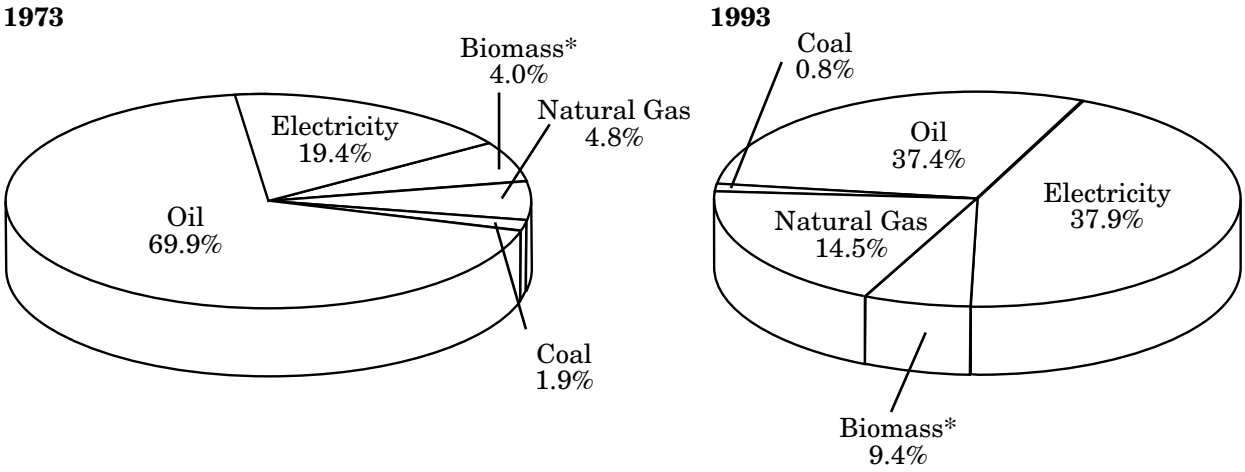
The acronym tep stands for "**T**on **E**quivalent **P**etroleum," or the equivalent of one tonne of petroleum. The tep is the basic metric unit used to indicate the energy produced by burning one tonne of petroleum. With this unit, we can compare the amount of energy produced by electricity, uranium or the burning of oil, natural gas or coal.

ENERGY AND HUMAN ACTIVITY

Humans have always used energy, but the ways they have used it have changed throughout history. In the beginning, people simply relied on the strength of their own arms or their beasts of burden. They gradually learned how to start a fire with wood and then used water and wind power to operate mills. They then invented machines that run on steam, coal, oil, hydroelectricity and, now, nuclear energy.

In a sense, we are spoiled because we have everything at our fingertips. However, unlike our relatively self-sufficient ancestors, we have become more dependent. How do you manage during a transit strike? What do you do during a power failure on a cold winter's night?

Figure 1.2
Energy Consumption in Québec by Type of Energy



* Biomass: organic, carbon-based matter that includes trees as well as urban waste.

Between 1973 and 1993, electricity consumption rose from 19.4% to 37.9% of total energy consumption, largely at the expense of oil consumption, which fell from 69.9% to 37.4% of total energy consumption over the same period.

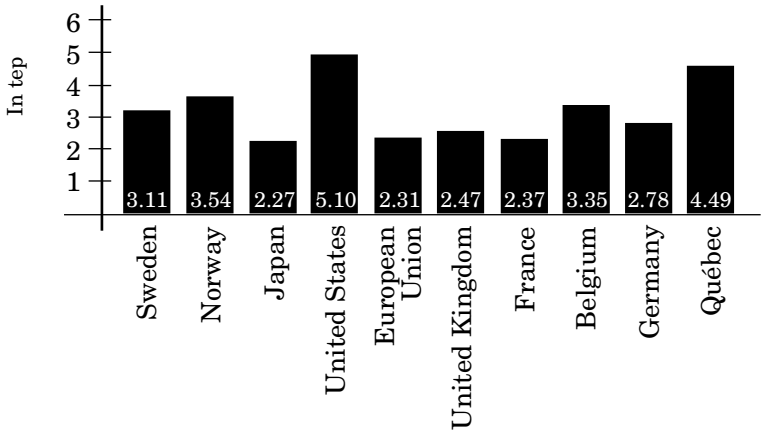
Source: Ministère des Ressources naturelles. *L'énergie au Québec*, 1995, p. 98. (Free translation)

Québec has an abundance of energy resources, using its many powerful rivers to produce a great deal of electricity. Québec is the fourth largest producer of hydroelectricity behind the United States, the former USSR and Brazil. In addition, western Canada and the oil producing countries supply this province with oil and natural gas. New technology has made it possible to harness wind and solar power. Of course, we shouldn't forget wood burning, which remains a popular way of heating homes.

Many parts of the world use nuclear energy. Ontario produces more than 50% of its electricity this way. Québec has only one of the world's 400 nuclear power stations. It is a remarkable source of energy even though it involves certain risks.

Regardless of where it comes from, energy is essential to our well-being. Quebecers are among the world's leading energy consumers.

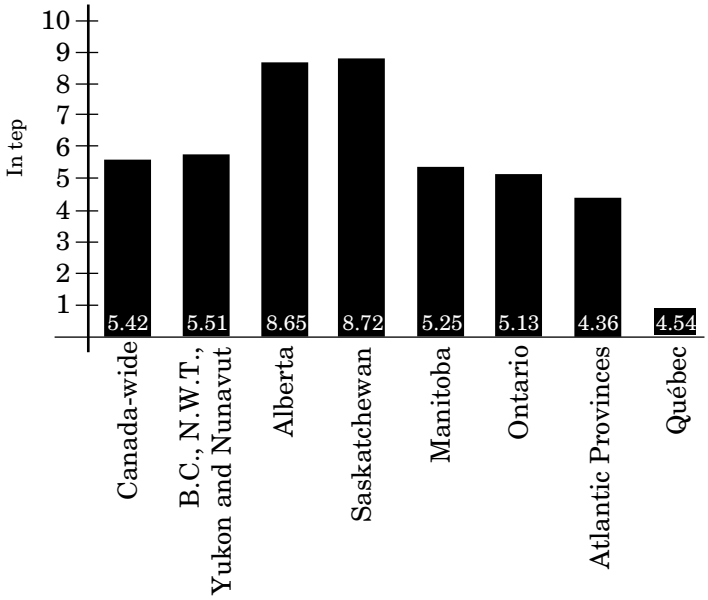
Figure 1.3
Per Capita Energy Consumption, Québec and Major Industrialized Countries (1992)



Québec is one of the world's leading energy consumers.

Source: Ministère des Ressources naturelles. *L'énergie au Québec*, 1995, p. 24. (Free translation)

Figure 1.4
Per Capita Energy Consumption, Québec and Other Canadian Provinces (1993)



In 1993, Québec's per capita energy consumption was one of the lowest in Canada.

Source: Ministère des Ressources naturelles. *L'énergie au Québec*, 1995, p. 20. (Free translation)

Of course, our harsh winters raise our heating bills, but that isn't the only factor. We have many cars that burn a lot of fuel. Our homes are equipped with a wide variety of appliances, and we can light up a room by simply flicking a switch.

1.2

Since hydroelectricity is the most widely used form of energy in Québec, any power failure greatly disrupts our daily lives.

Name five things you plan to do within the next 24 hours. For each activity, name other types of energy that could be used in case of a power failure.

Activities	Other Types of Energy

***1.3**

In addition to using hydroelectric dams, name two other ways in which Québec produces electricity. Give examples.

ENERGY AND ECONOMIC DEVELOPMENT

Energy is as essential to our economy as it is to our personal well-being. Québec's main industries consume large amounts of energy. Pulp and paper mills and aluminum factories, among others, use enormous quantities of electricity. The Deschambault aluminum plant alone requires as much electricity as the 500 000 people living in Greater Quebec City. In fact, many big companies have come to Québec because it has a large supply of cheap electricity. In Québec, energy is an important economic development factor that helps create jobs.

Table 1.1
Electricity Consumption by Sector, Québec (1993)

Sector	Millions of kWh	%
Industrial	76 637	48.23
Residential	51 189	32.21
Commercial	30 741	19.35
Transportation	333	0.21

Source: Ministère des Ressources naturelles. *L'énergie au Québec*, 1995, p. 69. (Free translation)

Table 1.2
Electricity Consumption in Selected Industries, Québec (1993)

Type of Industry	Millions of kWh	%
Smelting and Refining*	37 078	48.38
Pulp and Paper	18 269	23.84
Chemical	4 275	5.58
Iron and Steel	2 544	3.32
Mining	2 617	3.41
Cement	353	0.46

*E.g. foundries, aluminum plants, iron pelletizing plants.

Source: Ministère des Ressources naturelles. *L'énergie au Québec*, 1995, p. 71. (Free translation)

Do we have to consume that much energy to live prosperously and comfortably? It all depends on your point of view.

On average, the Japanese consume half as much energy as North Americans even though their climate resembles ours. Yet, they can hardly be considered poor. They have learned to get the most out of their meagre resources and have succeeded in developing one of the world's most vibrant economies.

This is not the case in the Third World. While we have easy access to electricity and oil, destitute countries often cannot afford such resources. For example, take the Sahel, one of the poorest regions of Africa. On average, one person in this part of the world consumes 80 times less energy than one person in Québec. These people cannot possibly afford to waste anything, because they don't even have the bare essentials!

Although everyone needs them, energy resources are not equally distributed. As a result, countries will take the drastic step of going to war to gain control over energy reserves. This is one of the factors that led to the 1990 war between Iraq and Kuwait. Energy resources have become a key element in international relations.

1.4

Which industries in your area can be considered major energy consumers?

_____

_____

_____

_____

1.5

a) In Québec, which sector uses the largest amount of energy?

_____

b) Name some industries in this sector.

_____

_____

c) Where does the residential sector rank in terms of energy consumption?

_____

ENERGY AND THE ENVIRONMENT

The distribution of energy resources is not the only problem. Environmental issues must also be considered. We now realize that energy production and consumption have disrupted our planet's ecology. Coal- or oil-fired power plants release carbon compounds into the atmosphere, accelerating the global warming process commonly known as the greenhouse effect.[2] Too often, supertankers run

2. A process by which the heat of the Sun remains trapped at the Earth's surface; this process is somewhat similar to what occurs in a greenhouse.

aground, resulting in oil slicks that endanger aquatic life. Cars spew out sulfur and nitrogen oxide which help create acid rain.

Until now, we have thought that hydroelectricity would solve many of these environmental problems. After all, hydroelectricity is renewable and still the cleanest of the main forms of energy because it does not pollute the atmosphere.

Nevertheless, the major debate over the James Bay megaprojects[3] has shown that hydroelectricity also has its disadvantages. To produce that much electricity, you have to build reservoirs, flood land, divert rivers, disrupt ecosystems,[4] displace people and change their way of life. We now know that the creation of these reservoirs releases the mercury found in the ground. The mercury poisons the fish and the people who eat them. This pollution especially affects the Cree and Inuit for whom fish is a staple.

Some also believe that the magnetic fields around electric power lines may be a health hazard. Although no scientific study has yet confirmed this, Dr. Rosemonde Mandeville of the Institut Armand Frappier is conducting research in this area by exposing rats to magnetic fields. Within a few years, scientists should be able to say whether this endangers human health in any way.

What should we do? We want to use this energy and even sell it to our neighbours. If our lifestyle does not change, we will have to obtain this energy one way or another.

1.6 Specify the social and environmental problems related to the production of hydroelectric energy.

_____

_____

_____

_____

_____

_____

3. Large-scale projects involving major investments and a wide range of activities.
4. A basic ecological unit consisting of a living environment and the organisms, animals and plants that live in it.

1.7

Indicate any environmental damage caused by each of the following sources of energy.

The Sun

_____

Burning wood

_____

Burning coal

_____

Creating reservoirs

_____

Burning oil

_____

Burning natural gas

_____

Harnessing windpower

_____

NUCLEAR ENERGY: AN ALTERNATIVE SOLUTION?

Should we now use nuclear energy? Nuclear power plant builders claim they can meet our needs. Nuclear power plants do not release sulfur or carbon into the atmosphere and do not call for large reservoirs. The main pollution problem is the always difficult task of eliminating radioactive waste.

In theory, nuclear power stations do less damage to the environment than any other type of power plant. They do, however, pose a serious problem. An accident in a nuclear reactor can be disastrous. A good example of this is the 1986 accident at the Chernobyl power plant in the Ukrainian Republic of the former USSR.

To complicate matters, we cannot talk about nuclear energy without mentioning atomic bombs and nuclear warheads. When two atomic bombs pulverized the Japanese cities of Hiroshima and Nagasaki in 1945, thousands of people died. Nuclear energy can also kill.

Humankind then strove to convert this devastating weapon into a tool for peace by developing new ways of using nuclear energy. We can now treat cancer patients and irradiate food so that it keeps longer. We can even use nuclear energy to travel by land, on or under the sea and in outer space!

With the problems that have discredited the other forms of energy, nuclear energy may now be given another chance. Its major advocates claim the time has come to build nuclear power stations. However, environmentalists maintain that it's too dangerous.

Québec has long steered clear of this debate because it has only one nuclear power station: the Gentilly plant near Trois-Rivières. Besides, water-powered turbines generate 95% of Québec's electricity. The demands of native peoples have, however, made it more difficult to develop new hydroelectric facilities. By saving on electricity, we could avoid building some power stations. We could also consider the nuclear option.

1.8 What environmental problems does nuclear energy supposedly solve?

_____

_____

_____

_____

1.9 Many people believe that nuclear energy involves greater risks than other forms of energy.

In your opinion, what are these fears based on?

_____

_____

_____

_____

MAKING AN INFORMED CHOICE

What should we do? Should we harness[5] other rivers, save even more energy, opt for nuclear energy, live more frugally? We will have to face these questions sooner or later. What do we need to know to make the right choice?

First, we have to determine what our society really needs and what role energy will play in our lives. Every person should reflect on this question.

To understand this issue, we have to go even further: we have to understand what nuclear energy is. In other words, we have to explore the very structure of matter because it was by unlocking the mysteries of matter that scientists discovered the potential of nuclear energy.

In this physical science course, we will go beyond the clichés to achieve a true understanding of nuclear energy. You will then find it easier to answer some of the major questions our society is now debating.

5. The proper expression is "to impound rivers."

Could Québec Go Nuclear?

By Alain Dubuc

Quebecers probably don't realize it, but Québec may well opt for nuclear energy by the end of the decade, marking a major change in the province's energy policy.

The obstacles to building hydroelectric dams in northern Québec are such that if nothing changes, the government and Hydro-Québec will eventually have to throw in the towel.

And if that happens, Québec won't turn into an environmental paradise overnight. Energy needs won't simply disappear, and nuclear energy will remain the only other economical source of energy. Don't be surprised if in the next few months, Hydro reconsiders the nuclear option it scrapped long ago.

Of course, those opposed to new dams hope that energy savings will offset the needs that new hydroelectric stations would have fulfilled.

These people are either incredibly naive or incredibly dishonest.

Yes, there's room for savings, but we aren't talking about minor savings here. For example, if we billed electricity as they do in New York, demand would certainly drop. We could force people to convert to natural gas. These are effective measures, but costly and painful. And they simply won't do within ten or fifteen years.

Is this a worst-case scenario? It certainly is, but it is more than plausible. In fact, it is highly likely. It also reminds us of something easily forgotten in the heat of the ecological debate: we have to look at the big picture when dealing with environmental issues.

We have to consider the future. For instance, this means thinking about the nuclear threat. From a global perspective, we also have to remember our neighbours in New England who, without our electricity, would have no choice but to use nuclear energy, coal or oil. All these factors must be taken into account.

With the Cree on one side, the pro-nuclear lobby on the other and the dams in the middle of it all, there are no easy answers, which is all the more reason not to approach this issue simplistically.

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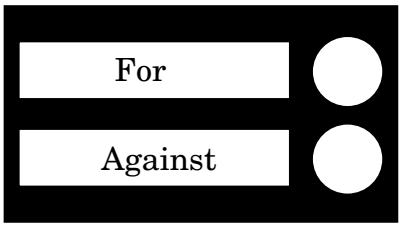
(This is a free translation.)
1991 06 29

1.10

If the Québec government held a referendum asking whether you were for or against using nuclear energy to produce electricity, how would you vote today?



a) Explain your position.

_____

_____

_____

b) Outline the main arguments of those opposed to your position.

_____

_____

_____

Key Words in the Chapter

Energy

Joule

Kilowatt-hour

Summary

Energy has left its stamp on our world. We depend on it for our personal well-being and overall economic development.

The need for energy has existed for thousands of years, but it has taken on a whole new dimension since the advent of industrial society. Coal, oil, hydroelectricity and, now, nuclear energy have changed our relationship with nature.

Quebecers have enough energy to live comfortably, which is not the case for everyone on this planet. The distribution of energy resources creates conflicts that can lead to war.

In addition, energy production and consumption has taken such a toll on the environment that it threatens the delicate balance of nature.

What can we do to reduce the risks while maintaining the benefits we now have. We can decide to save on energy or choose more efficient sources of energy.

Nuclear energy may be an alternative solution to our problems, but is it the best option? This course will give you the knowledge you will need to make your own informed choice.

Review Exercises

1.11

a) What type of energy production does the Québec government currently favour?

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b) On what grounds would it reconsider this choice?

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c) What other energy options would be available?

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1.12

Industry uses a great deal of electricity. Two types of industries consume especially large quantities of energy.

Identify these two types of industries.

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1.13

What environmental problems does nuclear energy supposedly solve?

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