

PHYSICAL SCIENCE

secondary IV

Nuclear Technology: A Matter of Energy

PSC-4010-2

DEFINITION OF THE DOMAIN
FOR SUMMATIVE EVALUATION

NOVEMBER 1998

PHYSICAL SCIENCE

secondary IV

Nuclear Technology : A Matter of Energy

PSC-4010-2

**DEFINITION OF THE DOMAIN
FOR SUMMATIVE EVALUATION**

NOVEMBER 1998

© Gouvernement du Québec
Ministère de l'Éducation, 1998 — 98-0886

ISBN 2-550-33969-X

Dépôt légal — Bibliothèque nationale du Québec, 1998

1. Introduction

This definition of the domain for summative evaluation describes and classifies the essential and representative elements of the *Physical Science* program—specifically, for the course PSC-4010-2: Nuclear Technology: A Matter of Energy. It presents an overview of the program, but should by no means replace the program itself. The purpose of defining the domain is to ensure that all summative evaluation instruments are consistent with the overall program.

The organization of this definition of the domain is the same as that of those of other courses. The content of each section is, however, specific to this course.

The goal of the definition of the domain for summative evaluation is to permit the preparation of examinations that are valid from one version to another, from year to year and from one school board to another, taking into account the responsibilities shared by the ministère de l'Éducation and the school boards.

2. Program Orientations and Consequences for Summative Evaluation

Orientations

One aim of the program is to help students acquire scientific knowledge, especially in physics and chemistry.

The program also aims to help students become citizens with an understanding of science and technology.

It is designed to help students acquire an understanding of physical and chemical phenomena.

It is also designed to acquaint students with the historical evolution of scientific and technological knowledge.

The program is intended to help students acquire technological knowledge related to scientific discovery.

In the program, the students are asked to analyze the social consequences of certain scientific discoveries and technological changes.

They are also asked to analyze the relationships between science, technology and society.

Consequences

The evaluation should verify the students' acquisition of scientific knowledge in physics and chemistry.

The evaluation should verify the students' understanding of the social, economic and political issues related to scientific and technological development.

The evaluation should verify the students' ability to understand physical and chemical phenomena and analyze results.

The evaluation should verify the students' knowledge of the events that led to the modification of certain scientific theories.

The evaluation should verify the students' acquisition of certain technological knowledge.

The evaluation should verify the students' understanding of the social consequences of certain scientific discoveries and technological changes.

The students will be asked to analyze a problem and express their point of view on the issue in question.

3. Content of the Program for Purposes of Summative Evaluation

Themes

- **Structure and classification of matter**
 - Atomic theories
 - Models (ancient Greeks, Dalton, Thomson, Rutherford, Bohr and simplified model currently in use)
 - Evolution of the atomic model over time
 - Simplified atomic model currently in use (first 20 elements)
 - Basic atomic particles (protons, neutrons and electrons)
 - Electron distribution
 - Periodic table of the elements
 - Atomic number
 - Mass number
 - Number of protons, neutrons and electrons
 - Position of chemical families (alkali metals, alkaline earth metals, halogens, noble gases), actinides, hydrogen, metals and non-metals
 - Atomic structure of isotopes
 - Calculation of atomic mass
- **Changes of matter**
 - Characteristics of physical, chemical and nuclear changes
 - Natural and artificial radioactivity
 - Ionization radiation and electromagnetic wave radiation
 - Characteristics of X-rays and alpha, beta and gamma radiation
 - Units of measure of radiation: curie, becquerel, rad, gray, rem and sievert
 - Mass lost and stability of the atomic nucleus of an isotope
 - Half-life of radioactive elements
 - Equations for radioactive decay
 - Nuclear fission
 - Nuclear fusion

- **Uses of nuclear energy**
 - Different uses of nuclear energy
 - Military uses: A-bomb, H-bomb
 - Production of electricity
 - Comparison with other types of power plants
 - Operation of nuclear reactors: Canada (CANDU) and other countries
 - Advantages, disadvantages and difficulties of using fission and fusion to produce electricity
 - Other
 - Irradiation of foods
 - Carbon-14 dating
 - Risks associated with the use of nuclear energy
 - Risks associated with the transformation of uranium
 - Risks associated with the use of uranium
 - Consequences of using nuclear energy
 - Health effects
 - Environmental effects
 - Effects on democracy
 - Advantages of using nuclear energy
 - Economic advantages
 - Environmental advantages
 - Advantages for research and development
 - Points of view for or against the use of nuclear energy

Skills

- **Knowing:** Stating the manifestations or components of a scientific or technical phenomenon.
- **Understanding:** Applying acquired knowledge to deduce information.
- **Analyzing:** Examining the components of a phenomenon in order to determine relationships.
- **Synthesizing:** Integrating, in a relevant and organized manner, different skills and themes with a view to defining or solving a problem or making a decision.

4. Table of Dimensions

In the preceding sections, the content was specified. The following table of dimensions illustrates the specific relationships between the themes and skills.

THEMES SKILLS	STRUCTURE AND CLASSIFICATION OF MATTER 22%	CHANGES OF MATTER 26%	USES OF NUCLEAR ENERGY 52%
KNOWING 24%	<ul style="list-style-type: none"> Position of metals, non-metals, hydrogen, actinides and chemical families in the periodic table (1) 3%	<ul style="list-style-type: none"> Units of measure of radiation Relationship between mass lost, isotope stability and energy liberated (4) 6%	<ul style="list-style-type: none"> CANDU reactor (3%) Nuclear fission and fusion to produce electricity (3%) Risks, disadvantages and advantages of using nuclear energy (9%) (7) 15%
UNDERSTANDING 36%	<ul style="list-style-type: none"> Evolution of the atomic model over time Information contained in the periodic table Calculation of the atomic mass of an element (2) 9%	<ul style="list-style-type: none"> Distinction between physical, chemical and nuclear changes (3%) Distinction between radioactivity, fission and fusion (3%) Relationship between the half-life of a radioactive element and the mass remaining (3%) Characteristics of alpha, beta and gamma radiation, X-rays and their effects on matter (6%) (5) 15%	<ul style="list-style-type: none"> A-bomb and H-bomb Operation of hydroelectric, conventional thermal and nuclear power plants Technology of CANDU reactors compared with that of other countries (former Soviet Union, United States and England) Use of radioactive elements in the field of medicine, for irradiating food and for dating objects using carbon 14 (8) 12%
ANALYZING 15%	<ul style="list-style-type: none"> Atomic theories (ancient Greeks, Dalton, Thomson, Rutherford, Bohr and simplified model currently in use) Atomic structure of the isotopes of an element (3) 10%	<ul style="list-style-type: none"> Information provided by an equation of radioactive decay (6) 5%	
SYNTHESIZING 25%			<ul style="list-style-type: none"> Points of view on the use of nuclear energy (9) 25%

5. Observable Behaviours

Dimension 1

Given a periodic table, locate the position of the metals, the non-metals, the alkali metals, the alkaline earth metals, the halogens, the noble gases, hydrogen and the actinides.

Dimension 2

Associate the atomic models (ancient Greeks, Dalton, Thomson, Rutherford, Bohr and the simplified model currently in use) with the historical events or technological discoveries that inspired them.

Referring to the periodic table, describe an element chosen from among the first 20: symbol, atomic number, atomic mass, number of protons, number of electrons, number of neutrons, number of the group and period, number of energy levels, number of electrons in the outermost energy level.

Given the mass number of an element and the relative abundance of its isotopes, calculate the atomic mass of that element.

Dimension 3

Explain the similarities and differences in consecutive atomic models.

Given the atomic notation of certain elements, find the isotopes of the same element and compare their structure.

Dimension 4

Associate the units of measure of radiation (curie, becquerel, rad, gray, rem and sievert) with what each of them measures (number of decays per second, energy, harmful potential).

Given a series of statements, select the one(s) that correctly describe the relationship between the energy released during a nuclear reaction, the mass defect and the stability of the resulting isotope.

Dimension 5

Given examples of changes of matter, identify the ones that represent physical, chemical or nuclear changes and explain the answer.

Given a series of statements describing nuclear reactions involving radioactivity, fission and fusion, select the correct statement(s).

Given the half-life of a radioactive element, apply the relationship between decay time and the mass that will remain.

Associate statements describing the characteristics of alpha, beta, and gamma radiation, X-rays and their effects on matter.

Dimension 6

Given an equation for radioactive decay, identify either the radioactive element, the element produced or the radiation produced and justify the answer.

Dimension 7

Select from among a series of statements those that correctly describe the role of the constituent elements of a CANDU reactor and the operation of the reactor.

State the advantages, disadvantages or difficulties of using nuclear fission or fusion to produce electricity.

Describe the risks associated with one of the steps involved in the preparation of uranium ore, its use in producing electricity or radioactive waste management.

Describe the consequences of using nuclear energy on human health or the environment.

Describe the social advantages of using nuclear energy (e.g. economic, environmental, research and development, health).

Dimension 8

Compare and contrast the A-bomb and the H-bomb with respect to their constituent elements, their power, the nuclear reactions involved or their destructive effects.

Compare and contrast the operation of hydroelectric, conventional thermal and nuclear power plants.

Compare and contrast the CANDU reactor and reactors used in the United States, England and the former Soviet Union.

Explain how or why radioactive elements are used in the field of medicine, to irradiate foods or to date objects using carbon 14.

Dimension 9

Present a current topic related to a use of nuclear energy:

- select a topic
- explain the scientific principles involved
- create a file of resource materials
- list the good and bad points
- list arguments for and against such a use
- explain the personal choice

6. Explanation of Content and Weighting

Some general objectives of the course and the program served as the basis for determining the importance of acquiring basic knowledge and of developing certain intellectual processes such as considering the importance of information, distinguishing between facts and opinions and analyzing various points of view before making a well-informed decision. This is why a weighting of 75% has been attributed to the acquisition of basic knowledge that can be used to support arguments based on facts rather than on opinions.

Furthermore, the presentation of the student's point of view on a topic related to the course content has been weighted at 25%. Part of this 25% will be devoted to the preparation of a file of resource material, which is an intellectual process essential to constructing a solid argument to express one's point of view on a given topic. This intellectual process is transferable to a number of real-life situations.

On the basis of the tasks prescribed in the terminal objectives, the weighting of the themes and skills has been established as follows:

- Knowing 24%
 - Understanding 36%
 - Analyzing 15%
 - Synthesizing 25%
-
- Structure and classification of matter 22%
 - Changes of matter 26%
 - Uses of nuclear energy 52%

7. Description of the Examination

7.1 Type of Examination

The summative evaluation consists of an examination in two parts.

The first part is a research project to measure Dimension 9, which is related to the student's ability to express an opinion based on facts and counts for 25% of the final mark.

The second part is a comprehensive examination to measure dimensions 1 through 8. It counts for 75% of the final mark and includes objective and short-answer test items.

All the observable behaviours for each dimension should be measured. Except for dimensions 5 and 7, the points allotted to a dimension are divided equally between the observable behaviours for that dimension.

7.2 Characteristics of the Examination

The research project is to be done during the course. The administrator's guide should explain the method of verifying the authenticity of the student's work.

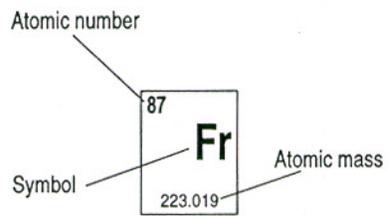
The second part of the examination should be taken at the end of the course, in a single sitting of no more than 120 minutes. The relevant information (e.g. numerical data, tables, newspaper or magazine articles) should accompany each question. A periodic table without the names of the elements will be provided (see appendix).

7.3 Pass Mark

To pass the course, students must obtain a combined total of 60 out of 100 for the two parts of the examination.

Periodic Table of the Elements

IA										VIII A																						
1 H 1.008																	2 He 4.002															
IIA																		III A	IV A	V A	VII A	VIII A										
3 Li 6.941	4 Be 9.012																	5 B 10.811	6 C 12.011	7 N 14.007	8 O 15.999	9 F 18.998	10 Ne 20.180									
11 Na 22.989	12 Mg 24.305																	13 Al 26.982	14 Si 28.086	15 P 30.974	16 S 32.066	17 Cl 35.453	18 Ar 39.948									
		IIIB	IVB	VB	VIB	VII B	VIII B		IB	IIB																						
19 K 39.098	20 Ca 40.078	21 Sc 44.956	22 Ti 47.88	23 V 50.942	24 Cr 51.996	25 Mn 54.938	26 Fe 55.847	27 Co 58.933	28 Ni 58.693	29 Cu 63.546	30 Zn 65.39	31 Ga 69.723	32 Ge 72.612	33 As 74.921	34 Se 78.96	35 Br 79.904	36 Kr 83.800															
37 Rb 85.468	38 Sr 87.62	39 Y 88.906	40 Zr 91.224	41 Nb 92.906	42 Mo 95.94	43 Tc 97.907	44 Ru 101.07	45 Rh 102.906	46 Pd 106.42	47 Ag 107.868	48 Cd 112.411	49 In 114.82	50 Sn 118.710	51 Sb 121.757	52 Te 127.60	53 I 126.904	54 Xe 131.29															
55 Cs 132.905	56 Ba 137.327																	72 Hf 178.49	73 Ta 180.948	74 W 183.85	75 Re 186.207	76 Os 190.200	77 Ir 192.22	78 Pt 195.080	79 Au 196.967	80 Hg 200.59	81 Tl 204.383	82 Pb 207.2 Plomb	83 Bi 208.980	84 Po 208.982	85 At 209.987	86 Rn 222.018
87 Fr 223.019	88 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 La 138.905	58 Ce 140.115	59 Pr 140.907	60 Nd 144.24	61 Pm 144.912	62 Sm 150.36	63 Eu 151.965	64 Gd 157.25	65 Tb 158.925	66 Dy 162.50	67 Ho 164.930	68 Er 167.26	69 Tm 168.934	70 Yb 173.04	71 Lu 174.967
89 Ac 227.027	90 Th 232.038	91 Pa 231.036	92 U 238.029	93 Np 237.048	94 Pu 244.064	95 Am 243.061	96 Cm 247.070	97 Bk 247.070	98 Cf 251.079	99 Es 252.083	100 Fm 257.095	101 Md 258.098	102 No 259.100	103 Lr 260.105

