Unit Title: Nuclear Chemistry

Unit Goals:

· Explore the nature and structure of the atomic nucleus with regard to its stability and decay.

· Examine the sundry ways that nuclear changes affect daily life and the applications of radio-isotopes in various scientific fields.

· Discover and thoroughly discuss the issues which surround the use of nuclear energy obtained from fission reactors.

· Strengthen overall analytical thinking and communication skills by building and utilizing simulation models to predict a first order reaction, using the internet as a research tool, participating in group discovery and publicly presenting and defending a research based opinion.

Grade Level: 9-12

General Subject Area: Chemistry

Minimum time required for the unit: two weeks

Concepts learned across all unit modules:

· Nuclear particles and their charges
· Isotopes and atomic mass
· Nuclear binding energy
· Alpha and beta decay
· Half-life
· Fission and fusion

Standards addressed across the unit:

Maryland State Department of Education High School Science Core Learning Goals

Goal/Expectation	Description
Goal 1	The student will demonstrate ways of thinking and acting inherent in the practice of science. The student will use the language and instruments of science to collect, organize, interpret, calculate, and communicate information.
1.1	The student will explain why curiosity, honesty, openness, and skepticism are highly regarded in science.
1.4	The student will demonstrate that data analysis is a vital aspect of the process of scientific inquiry and communication.
1.5	The student will use appropriate methods for communicating in writing and orally the processes and results of scientific investigation.
1.6	The student will use mathematical processes.
1.7	The student will show that connections exist both within the various

	fields of science and among science and other disciplines including mathematics, social studies, language arts, fine arts, and technology.
Goal 4	The student will demonstrate the ability to use scientific skills and processes to explain composition and interactions of matter in the world in which we live.
4.2	The student will explain that all matter has structure and the structure serves as the basis for the properties of and the changes in matter.
4.5	The student will investigate the impact of chemistry on society.

Technology needed in unit modules:
Internet, video, computer modeling software

Technology-enhanced instructional strategies employed:
Tele-research, modeling

Title of each module:
Module 1: What is the nucleus of an atom?
Module 2: Why are some nuclei unstable?
Module 3: What are some of the ways that nuclei become stable?
Module 4: What are fission and fusion?

Unit culminating activity:
Oral presentation and defense of a research-based opinion

Unit author: Doria Hillsman

Unit contributors: Daniel Ku and Tina Peng

Module #1

Module Title: What is the nucleus of an atom?

Estimated time to complete: 90 minutes

Module objectives: Students will build a basic understanding of the nucleus.

Concepts learned in this module:
- Nuclear particles and their charges
- Isotopes
- Atomic mass

Standards addressed in this module:
Maryland State Department of Education High School Science Core Learning Goals

Goal/Expectation	Description
Goal 1	The student will demonstrate ways of thinking and acting inherent in the practice of science. The student will use the language and instruments of science to collect, organize, interpret, calculate, and communicate information.
Goal 4	The student will demonstrate the ability to use scientific skills and processes to explain composition and interactions of matter in the world in which we live.
4.2	The student will explain that all matter has structure and the structure serves as the basis for the properties of and the changes in matter.

Technology-enhanced instructional strategies utilized in this module:
Web-based tutorial

MODULE OVERVIEW

Components	Brief description of module activities	Student Grouping	Materials/ Technology
Engagement	Construct physical models of nuclei	Individual	Petri dish bottoms and pith balls
Exploration	Atomic nucleus research to answer: · What is the average radius/density of the atomic nucleus? · How are all of the protons in the nucleus able to remain so close to each other? · How does the nucleus relate to the mass of an element? · What is an isotope? Give some common isotopes and list the number of protons and neutrons in each.	Groups	Textbook and reference materials

Explanation/ Extension	Jigsaw activity to learn more about nuclear particles. After exploring the topic "What is fundamental?" as a class, assign remaining 8 subtopics to groups and then jigsaw to share information.	Groups	The Particle Adventure at http:// ParticleAdventure. org/English/ Index.html
Evaluation	Unit Test after Module 3	Individual	

Expected module outcomes:
Students will understand the basic properties of the nucleus.

Performance-based assessment of module outcomes:
Written test after Module 3

Module #2

Module Title: Why are some nuclei unstable?

Estimated time to complete: 45 minutes

Module objectives: Students will build an understanding of unstable nuclei.

Concepts learned in this module:
- Strong force
- Nuclear binding energy
- Mass defect
- Proton/neutron ratios
- Transmutation
- Alpha and beta decay

Standards addressed in this module:
Maryland State Department of Education High School Science Core Learning Goals

Goal/Expectation	Description
Goal 1	The student will demonstrate ways of thinking and acting inherent in the practice of science. The student will use the language and instruments of science to collect, organize, interpret, calculate, and communicate information.
Goal 4	The student will demonstrate the ability to use scientific skills and processes to explain composition and interactions of matter in the world in which we live.
4.2	The student will explain that all matter has structure and the structure serves as the basis for the properties of and the changes in matter.

Technology-enhanced instructional strategies utilized in this module:
Web-based research

MODULE OVERVIEW

Components	Brief description of module activities	Student Grouping	Materials/ Technology
Engagement	Account for the "missing" mass in an atom	Class	
Exploration	Textbook reading	Individual	Textbook
Explanation	Nuclear binding energy discussion	Class	
Extension	Transmutation and transuranium elements	Groups	ABC's of Nuclear Science http://www.lbl.gov/abc/Basic.html
Evaluation	Unit test after Module 3	Individual	

Expected module outcomes:
Students will understand the forces which cause a nucleus to be unstable.

Performance-based assessment of module outcomes:
Unit test after Module 3

Module #3

Module Title: What are some of the ways that nuclei become stable?

Estimated time to complete: 90 minutes

Module objectives: Students will build an understanding of radioactive decay.

Concepts learned in this module:
- Alpha and beta decay
- Half-life

Standards addressed in this module:
Maryland State Department of Education High School Science Core Learning Goals

Goal/Expectation	Description
Goal 1	The student will demonstrate ways of thinking and acting inherent in the practice of science. The student will use the language and instruments of science to collect, organize, interpret, calculate, and communicate information.
1.1	The student will explain why curiosity, honesty, openness, and skepticism are highly regarded in science.
1.4	The student will demonstrate that data analysis is a vital aspect of the process of scientific inquiry and communication.
1.5	The student will use appropriate methods for communicating in writing and orally the processes and results of scientific investigation.
1.6	The student will use mathematical processes.
Goal 4	The student will demonstrate the ability to use scientific skills and processes to explain composition and interactions of matter in the world in which we live.
4.2	The student will explain that all matter has structure and the structure serves as the basis for the properties of and the changes in matter.

Technology-enhanced instructional strategies utilized in this module:
Web-based research, computer model

MODULE OVERVIEW

Components	Brief description of module activities	Student Grouping	Materials/ Technology
Engagement	"It's in the Clouds" demonstration	Class	http://www.lbl.gov/abc/experiments/Experiment9.html
Exploration	Research the following terms: alpha and beta decay, gamma radiation, half-life.	Groups	Laser Disc – Chemistry at Work – video clip

Explanation	Class discussion	Class	
Extension	STELLA model of nuclear decay	Groups	Computer lab
Evaluation	Unit test	Individual	

Expected module outcomes:
Students will understand half-life and radioactive decay.

Performance-based assessment of module outcomes:
STELLA model of assigned isotopes
Written test

Module #4

Module Title: What are fission and fusion?

Estimated time to complete: 225 minutes

Module Objectives: Students will learn about nuclear fission and fusion.

Concepts learned in this module:
- Fission
- Fusion
- Historical perspectives of nuclear science

Standards addressed in this module:
Maryland State Department of Education High School Science Core Learning Goals

Goal/Expectation	Description
Goal 1	The student will demonstrate ways of thinking and acting inherent in the practice of science. The student will use the language and instruments of science to collect, organize, interpret, calculate, and communicate information.
1.1	The student will explain why curiosity, honesty, openness, and skepticism are highly regarded in science.
1.5	The student will use appropriate methods for communicating in writing and orally the processes and results of scientific investigation.
1.7	The student will show that connections exist both within the various fields of science and among science and other disciplines including mathematics, social studies, language arts, fine arts, and technology.
Goal 4	The student will demonstrate the ability to use scientific skills and processes to explain composition and interactions of matter in the world in which we live.
4.2	The student will explain that all matter has structure and the structure serves as the basis for the properties of and the changes in matter.
4.5	The student will investigate the impact of chemistry on society.

Technology-enhanced instructional strategies utilized:
Tele-research

MODULE OVERVIEW

Components	Brief description of module activities	Student Grouping	Materials/ Technology
Engagement	Show PBS documentary of Chernobyl Accident	Class	PBS video

Exploration	1) Construct a ten item multiple choice quiz about nuclear fission and fusion. 2) Worksheet to have students determine their personal exposure to radiation	Groups Individual	http://www.atomicarchive.com
Explanation	Field trip to University of Maryland nuclear power plant / student guest speaker from UM .	Class	
Extension	Hold a brief mock trial for President Harry S. Truman to determine whether or not his decision to bomb Hiroshima and Nagasaki was ethical.	Class	
Evaluation	Have students research the history of radioisotope discovery and the ways that radiation science has been used both to benefit and harm humankind. Students should then construct a 350 word essay on the subject which should trace the medical, scientific and technological breakthroughs that radiation science has provided.	Individual	Internet sites Word processing software

Expected module outcomes:
Students will understand both the benefits and dangers of the discoveries made through radiation science.

Performance-based assessment of module outcomes:
- Student-constructed quiz
- Mock trial participation
- Radiation science essay evaluated based on a rubric