Senior High School

DepED
DEPARTMENT OF EDUCATION

Physical Science

Quarter 1 – Module 1:

Exploring the Formation of Elements During Stellar Formation and Evolution

ALTERNATIVE DELIVERY MODE
ADM

Physical Science
Alternative Delivery Mode
Quarter 1 – Module 1: Exploring the Formation of Elements During Stellar Formation and Evolution
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Secretary: Leonor Magtolis Briones
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Development Team of the Module

Authors: Beverly Joy O. Lorenzo

Editors: Joey H. Villanueva, Arlene C. Malaybalay

Reviewers: Tommy R. Rico, Emiterio D. Macarubbo, Maricris N. Surigao

Illustrator: Daniel A. Lorenzo

Layout Artist: Justine C. Montoya

Management Team: Wilfredo E. Cabral, Director IV
Jennifer Vivas, CLMD Chief
Dennis M. Mendoza, Regional EPS in-charge of LRMS
Micah S. Pacheco, Regional ADM Coordinator
Jocelyn M. Aliñab, CID Chief
Tommy R. Rico, Division in-charge of LRMS and Division ADM Coordinator

Department of Education – National Capital Region

Office Address: Misamis St., Bago Bantay, Quezon City
Telefax: 02-929-0153
E-mail Address: depedncr@deped.gov.ph

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Introductory Message

For the facilitator:

Welcome to the Physical Science Grade 11/12 Alternative Delivery Mode (ADM) Module with the topic on formation of heavier elements during star formation and evolution, and synthesis of new elements in the laboratory!

This module was collaboratively designed, developed, and reviewed by educators to assist you, the teacher or facilitator, in helping the learners meet the standards set by the K to 12 Curriculum while overcoming their personal, social, and economic constraints in schooling.

This learning resource hopes to engage the learners in guided and independent learning activities at their own pace and time. Furthermore, this also aims to help learners acquire the needed 21st century skills while taking into consideration their needs and circumstances.

In addition to the material in the main text, you will also see this box in the body of the module:

Notes to the Teacher

This contains helpful tips or strategies that will help you in guiding the learners.

As a facilitator, you are expected to orient the learners on how to use this module. You also need to keep track of the learners' progress while allowing them to manage their own learning. Furthermore, you are expected to encourage and assist the learners as they do the tasks included in the module.

For the learner:

Welcome to the Physical Science 11/12 Alternative Delivery Mode (ADM) Module with the topic on formation of heavier elements during star formation and evolution, and synthesis of new elements in the laboratory!

Our hands are one of the most symbolized parts of the human body. It is often used to depict skill, action, and purpose. Through our hands we may learn, create and accomplish. Hence, the hand in this learning resource signifies that you as a learner is capable and empowered to successfully achieve the relevant competencies and skills at your own pace and time. Your academic success lies in your own hands!

This module was designed to provide you with fun and meaningful opportunities for guided and independent learning at your own pace and time. You will be able to process the contents of the learning resource while being an active learner.

This module has the following parts and corresponding icons:

 ***What I Need to Know***	This will give you an idea of the skills or competencies you are expected to learn in the module.
 ***What I Know***	This part includes an activity that aims to check what you already know about the lessons. If you get all the answers correct (100%), you may decide to skip this module.
 ***What's In***	This is a brief drill or review to help you link the current lesson with the previous one.
 ***What's New***	In this portion, the new lesson will be introduced to you in various ways such as a story, a song, a poem, a problem opener, an activity, or a situation.
 ***What is It***	This section provides a brief discussion of the lesson. This aims to help you discover and understand new concepts and skills.
 ***What's More***	This comprises activities for independent practice to solidify your understanding and skills of the topic. You may check the answers to the exercises using the Answer Key at the end of the module.
 ***What I Have Learned***	This includes questions or blank sentences/paragraphs to be filled in to process what you learned from the lesson.

 ***What I Can Do***	This section provides an activity that will help you transfer your new knowledge or skill I into real-life situations or concerns.
 ***Assessment***	This is a task which aims to evaluate your level of mastery in achieving the learning competency.
 ***Additional Activities***	In this portion, another activity will be given to you to enrich your knowledge or skill of the lesson learned. This also tends retention of learned concepts.
 ***Answer Key***	This contains answers to all activities in the module.

At the end of this module you will also find:

References	This is a list of all sources used in developing this module.

The following are some reminders in using this module:

1. Use the module with care. Do not put unnecessary mark/s on any part of the module. Use a separate sheet of paper in answering the exercises.
2. Don't forget to answer *What I Know* before moving on to the other activities included in the module.
3. Read the instruction carefully before doing each task.
4. Observe honesty and integrity in doing the tasks and checking your answers.
5. Finish the task at hand before proceeding to the next.
6. Return this module to your teacher/facilitator once you are through with it.

If you encounter any difficulty in answering the tasks in this module, do not hesitate to consult your teacher or facilitator. Always bear in mind that you are not alone.

We hope that through this material, you will experience meaningful learning and gain a deep understanding of the relevant competencies. You can do it!

What I Need to Know

This module was designed and written with you in mind. It is to help you master the formation of heavier elements during star formation and evolution, and synthesis of new elements in the laboratory. The scope of this module permits it to be used in many different learning situations. The language used recognizes the diverse vocabulary level of students. The lessons are arranged to follow the standard sequence of the course.

The module consists of one lesson only:

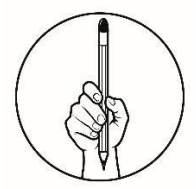
- Lesson 1 – Formation of Elements During Stellar Formation and Evolution

After going through this module, you are expected to:

1. Describe the formation of heavier elements during the formation and evolution of stars;
2. Cite astronomical evidence which justifies the formation of elements during stellar formation and evolution;
3. Appreciate the importance of the discovery of atomic number which led to the synthesis of new elements in the laboratory.

Notes to the Teacher

This module provides learning activities which encourage self-directed learning. Moreover, your role is to facilitate the learning process by providing a clear understanding on how to maximize the use of this module, monitor the development of our learners, scaffold the acquisition of learning to achieve target mastery level and provide positive feedbacks regarding their progress.



What I Know

DIRECTIONS: Read each question carefully. Choose the letter of the best answer. Write your answer on a separate sheet of paper.

1. Which of the following asserts that stars are formed when a dense region of molecular cloud collapse?
   a. Big Bang Theory
   b. Evolution Theory
   c. Creation Theory
   d. Star Formation Theory
2. Which refers to the fragments of clouds that contract and form a stellar core?
   a. Protostar b. Red giant c. Supernova d. White dwarf
3. What will be formed when a protostar attains its gravitational equilibrium?
   a. Main sequence star
   b. Red Giant
   c. Supernova
   d. White dwarf
4. Where do hydrogen and helium fuse in a main sequence star?
   a. Core b. Crust c. Inner core d. Mantle
5. Helium will be converted into what after its fusion with two more helium atoms?
   a. Argon b. Carbon c. Chlorine d. Oxygen
6. When a star has used up all the hydrogen in its core, hydrogen will be converted into helium in the layer immediately surrounding the core. What stage of star formation is this?
   a. Protostar b. Red giant c. Supernova d. White dwarf
7. During red giant formation, what element will be produced by the fusion of oxygen with helium?
   a. Helium b. Hydrogen c. Neon d. Silicon
8. During red giant formation, what element will be produced by the fusion of neon with helium?
   a. Carbon b. Magnesium c. Manganese d. Silicon
9. During red giant formation, what element will be produced by the fusion of silicon with another silicon atom?
   a. Argon b. Boron c. Iron d. Gold
10. At what stage does the outer covering of a star blow due to insufficient energy?
    a. Protostar b. Red giant c. Supernova d. White dwarf
11. What will happen to a star if its core can no longer produce the needed energy?
    a. Protostar b. Red giant c. Supernova d. White dwarf
12. Who predicted new elements based on the atomic number of known elements?
    a. Ernest Rutherford b. John Newlands c. Henry Mosely d. Plato
13. What type of nuclear reaction emits a particle with two protons and two neutrons?
    a. Alpha emission b. Beta emission c. Gamma emission d. Fusion
14. What type of nuclear reaction emits electrons?
    a. Alpha emission b. Beta emission c. Gamma emission d. Fission
15. What type of nuclear reaction emits gamma rays?
    a. Alpha emission b. Beta emission c. Gamma emission d. Fusion

1 Formation and Synthesis of Heavier Elements

"In one of the most inhospitable places in our galaxy, stars have prevailed. It appears that star formation is much more tenacious than we previously believed."

-Sergei Nayakshin

What's In

DIRECTIONS: Demonstrate understanding of primordial elements formation by completing the table below.

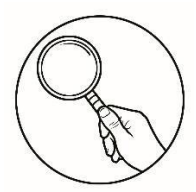
Elements	Reactants 1	Reactants 2	Nuclear Reaction
Deuterium			
Tritium			
Helium (Stable)			
Lithium			

What's New

Stellar Word Puzzle

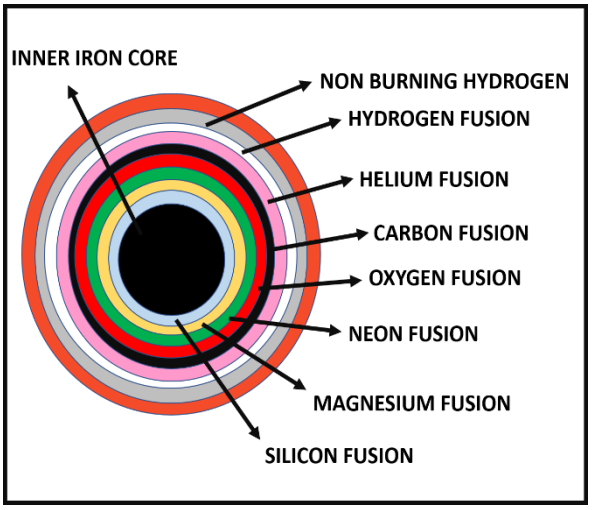
Directions: Encircle and write down the words which are related to star and element formation. In addition, expand your vocabulary by finding the meaning of the encircled words and relate them to your prior knowledge.

N	**U**	**C**	**L**	**E**	**O**	**S**	**Y**	**N**	**T**	**H**	**E**	**S**	**I**	**S**	**G**	**B**	**E**	**T**	**A**
S	**D**	**A**	**J**	**L**	**H**	**Y**	**D**	**R**	**O**	**G**	**E**	**N**	**A**	**L**	**P**	**H**	**A**	**I**	**I**
T	**U**	**T**	**H**	**E**	**L**	**I**	**U**	**M**	**S**	**U**	**N**	**S**	**T**	**A**	**B**	**L**	**E**	**A**	**B**
A	**S**	**O**	**R**	**M**	**N**	**U**	**C**	**L**	**E**	**U**	**S**	**N**	**U**	**C**	**L**	**E**	**I**	**D**	**T**
R	**T**	**M**	**D**	**E**	**F**	**U**	**S**	**I**	**O**	**N**	**R**	**A**	**D**	**I**	**A**	**T**	**I**	**O**	**N**
C	**O**	**C**	**H**	**N**	**F**	**I**	**S**	**S**	**I**	**O**	**N**	**G**	**A**	**M**	**M**	**A**	**S**	**G**	**N**
F	**I**	**V**	**R**	**T**	**P**	**R**	**O**	**T**	**O**	**S**	**T**	**A**	**R**	**M**	**H**	**D**	**R**	**S**	**V**
H	**F**	**L**	**F**	**S**	**U**	**P**	**E**	**R**	**N**	**O**	**V**	**A**	**G**	**J**	**D**	**H**	**T**	**A**	**C**



What is It

Evolution of Stars and the Formation of Heavier Elements



Star formation theory states that stars are formed when a dense region of molecular cloud collapses. During this process, fragments of clouds contract and form a stellar core known as **protostar**. The contraction and gravitational force of the protostar result in an increase in temperature which triggers nuclear reaction within the star upon reaching 10 million Kelvin. Throughout the reaction, neutrinos and positrons are released, slowing down the reaction. Once the contraction stops and the protostar attains its gravitational equilibrium, a main sequence star will be formed.

In the core of a main sequence star, hydrogen fuses with helium through proton-proton chain. In addition, the gravitational force of a main sequence star forces hydrogen and helium to fuse resulting to burning of the 2 primordial elements. Furthermore, at this stage, helium is converted to carbon at the core while hydrogen is converted into helium surrounding the core which denotes the formation of **red giant**. On the other hand, since massive stars possess enough energy, mass, temperature, and pressure, the star will undergo a series of stages where heavier elements are fused around the shell of the core whereas carbon will be formed through helium fusion, neon will be formed through oxygen fusion, magnesium from neon fusion, silicon from magnesium fusion, and iron from silicon fusion which denotes the formation of **red giant**.

Considering that the majority of helium surrounding the core has been converted into carbon, the rate of reaction will decrease causing the gravitational force to act squeezing the entire star. With low mass stars, considering that the amount of energy is not enough to sustain the reaction, and that the star's fuel has been exhausted, the outer material covering the star will eventually be blown-off leaving an inert carbon core resulting to the formation of **white dwarf**.

The first 3 minutes of Big Bang focused primarily on the expansion and cooling of universe so as to the synthesis of the first three elements. On the other hand, the second cosmological event is **Stellar nucleosynthesis**, a process in which heavier elements such as Beryllium ($_{4}$Be) and Iron ($_{26}$Fe) were formed by combining protons and neutrons from the nuclei of a lighter elements.

Moreover, under the process of stellar nucleosynthesis, heavier elements are created in different types of stars as they die or explode and the abundance of these elements change as the stars evolve.

Stable Helium reacts with Carbon to produce oxygen and gamma rays under extreme gravitational force and temperature. Oxygen as the product of the initial reaction then reacts with Helium to form Neon and gamma rays ($^{4}_{2}He + ^{16}_{8}O \longrightarrow ^{20}_{10}Ne + ^{0}_{0}\gamma$). The third reaction involves carbon reacting with another Carbon forming Magnesium and gamma ray ($^{12}_{6}C + ^{12}_{6}C \longrightarrow ^{24}_{12}Mg + ^{0}_{0}\gamma$). On the other hand, Oxygen to Oxygen fusion will create Silicon, alpha particle (Helium) and gamma rays as product. ($^{16}_{8}O + ^{16}_{8}O \longrightarrow ^{28}_{14}Si + ^{4}_{2}He + ^{0}_{0}\gamma$). The process will continue to form heavier elements from lighter ones, but not heavier than Iron with atomic mass of 26. Lastly, **supernova** happens when the core can no longer produce the needed energy to resist gravitational force, leading to its explosion and release of large amounts of energy.

Pieces of Evidence

One remarkable evidence to support stellar nucleosynthesis and star formation theory is the discovery of interstellar dusts and gasses which justifies the stages of stellar formation which are happening across the universe. In addition, infrared radiation being emitted in the process of stellar formation serves as a strong indication that stellar nucleosynthesis is a concurrent with stellar formation and evolution.

Atomic Number and Synthesis of New Elements

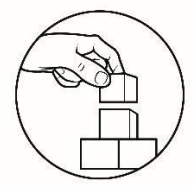
Throughout history, scientist have been working on a periodic organization of elements as to their properties and to predict new elements. This is because understanding the properties of these known elements will provide them a pattern which would help them discover new elements. Henry Gwyn Jeffreys Mosely an English chemist arranged the elements in the periodic table by using atomic number as basis. This allowed him to identify and predict any element considering the number of protons which is equal to the atomic number. In addition, he emphasized that adding proton to an element increases its atomic number and that new element will be formed.

Nuclear Reaction

Alpha Emission: a particle with two protons and two neutrons is emitted resulting to a lighter new element. $^{238}_{92}\mathbf{U} \longrightarrow ^{234}_{90}\mathbf{Th} + ^{4}_{2}\mathbf{He}$

Beta Emission: a neutron becomes a proton, and an electron will be ejected resulting to a new element with the same mass. $^{131}_{53}\mathbf{I} \longrightarrow ^{131}_{54}\mathbf{Xe} + ^{0}_{-1}\mathbf{e}$

Gamma Emission: gamma ray will be emitted when a radioactive nuclide leaves a nucleus in an excited state. $^{137}_{56}\mathbf{Ba} \longrightarrow ^{137}_{56}\mathbf{Ba} + \gamma$-photon.



What's More

Activity 1 Stellar Products

Directions: Based on your understanding about the formation of heavier elements during stellar nucleosynthesis, predict the reactants, and products which will be formed by the following reactions inside the table.

Reactant 1	Reactant 2	Atomic # of Reactant 2	Mass # of Reactant 2	Chemical Equation	Product
Helium	Oxygen				
Helium	Neon				
Helium	Magnesium				
Helium	Silicon				
Helium	Sulfur				
Helium	Argon				
Helium	Calcium				
Helium	Titanium				

Activity 2 Birth from the Stars

Directions: Identify the elements formed during the following stages of star formation and evolution.

Stages	What were the elements formed?	How were these elements formed?
Protostar		
Main Sequence Star		
Red Giant Star		
White Dwarf		
Supernova		

Activity 3 It's Okay Decay

Directions: Determine the type of chemical reaction in each item (a-emission, b-emission, y-emission, fission, fusion). In addition, write the product of the following chemical reactions on the space provided for product side.

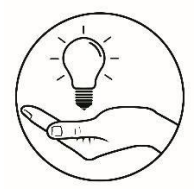
_____1. $_{15}{}^{32}P$ → $_{16}{}^{32}S$ + _____

_____2. $_{92}{}^{238}U$ → $_{90}{}^{234}Th$ + _____

_____3. $_{90}{}^{234}Th$ → $_{90}{}^{234}Th$ + _____

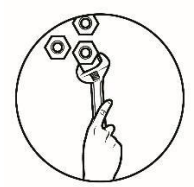
_____4. $_{53}{}^{131}I$ → $_{54}{}^{131}Xe$ + _____

_____5. $_{88}{}^{226}Ra$ → $_{86}{}^{222}Rn$ + _____



What I Have Learned

1. Gamma Ray is electromagnetic radiation with a relatively short wavelength emitted during gamma decay and other reactions.
2. Radio Active Nuclei refers to an unstable nucleus that spontaneously emits particles and energy throughout the radioactive decay process.
3. Supernova is a star that blows apart and releases a large amount of energy.
4. Star formation theory proposes that stars were formed due to the collapsing of a dense region of molecular clouds.
5. Stellar nucleosynthesis refers to the process by which elements are formed within the star during star formation and evolution.



What I Can Do

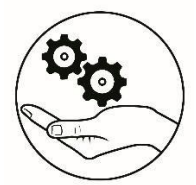
Directions: Based on your understanding of this module, analyze and answer the following questions regarding element formation during star formation and synthesis of new elements in the laboratory.

1. Describe the formation of primordial elements during the early stage of stellar formation and evolution.
2. Compare and contrast the elements formed by a small star and a massive star.
3. Describe the role being played by gravitational force in the creation of new elements.
4. Discuss the pieces of evidence used by scientists to explain the formation of heavier elements during stellar formation and evolution.
5. How did the discovery of atomic number revolutionize how we view the periodic table of elements as a tool in predicting new elements?
6. Describe how elements in the laboratory are synthesized.
7. Discuss how the elements formed in the star reached distant places/galaxies?
8. How did the discovery of atomic number pave the way to the synthesis of new elements in the laboratory?

Assessment

Directions: Read each question carefully. Choose the letter of the best answer. Write your answer on a separate sheet of paper.

1. When helium atoms fuse, Helium will be converted to_____.
   a. Argon b. Carbon c. Chlorine d. Oxygen
2. _____will be formed when protostar attains its gravitational equilibrium.
   a. Main sequence star c. Supernova
   b. Red Giant d. White dwarf
3. Hydrogen and helium fuse at the _____of a main sequence star.
   a. Core b. Crust c. Inner core d. Mantle
4. _____will be produced by silicon fusion during red giant formation.
   a. Argon b. Boron c. Iron d. Gold
5. _____predicted new elements based on the atomic number of known elements.
   a. Ernest Rutherford b. John Newlands c. Henry Mosely d. Plato
6. _____will be produced by oxygen fusion during red giant formation.
   a. Helium b. Hydrogen c. Neon d. Silicon
7. During the formation of a _____ hydrogen will be converted into helium in the layer surrounding the core.
   a. Protostar b. Red giant c. Supernova d. White dwarf
8. _____states that stars are formed when a dense region of molecular cloud collapse.
   b. Big Bang Theory c. Creation Theory
   c. Evolution Theory d. Star formation Theory
9. Two protons and two neutrons will be emitted during_____decay.
   a. Alpha b. Beta c. Gamma d. Fusion
10. ___will happen to a star if its core can no longer produce the needed energy.
   a. Protostar b. Red giant c. Supernova d. White dwarf
11. __will be produced by neon fusion during red giant formation.
   a. Carbon b. Magnesium c. Manganese d. Silicon
12. Gamma ray will be emitted during_____decay.
   a. Alpha b. Beta c. Gamma d. Fusion
13. When the fragments of clouds contract, a stellar core known as____ is formed.
   a. Protostar b. Red giant c. Supernova d. White dwarf
14. Electron will be emitted during__decay.
   a. Alpha b. Beta c. Gamma d. Fission
15. During_____stage the outer covering of star will blow due to insufficient energy.
   a. Protostar b. Red giant c. Supernova d. White dwarf

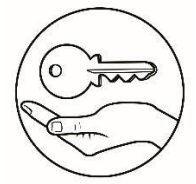


Additional Activities

Directions: Write the balanced nuclear reaction of the following elements under alpha, beta and gamma decay.

ELEMENT	RADIO ACTIVE DECAY	BALANCED CHEMICAL REACTION
Uranium 235	ALPHA DECAY	
	BETA DECAY	
	GAMMA DECAY	

ELEMENT	RADIO ACTIVE DECAY	BALANCED CHEMICAL REACTION
Uranium 238	ALPHA DECAY	
Carbon 14	BETA DECAY	
Barium 137	GAMMA DECAY	



Answer Key

What I Know

1.	D	9.	C					
2.	A	10.	D					
3.	A	11.	C					
4.	A	12.	C					
5.	B	13.	A					
6.	B	14.	B					
7.	C	15.	C					
8.	B							

Assessment

1.	B	9.	A					
2.	A	10.	C					
3.	A	11.	B					
4.	C	12.	C					
5.	C	13.	A					
6.	C	14.	B					
7.	B	15.	D					
8.	D							

What's More

Activity 1

Reactant 2	A #	M #	Chemical Equation	Prod
Oxygen	16	8	$_2^4He + {}_8^{16}O \rightarrow {}_1^3Ne$	Ne
Neon	20	10	$_2^4He + {}_{10}^{20}Ne \rightarrow {}_1^3Mg$	Mg
Magnesium	24	12	$_2^4He + {}_{12}^{24}Mg \rightarrow {}_1^3Si$	Si
Silicon	28	14	$_2^4He + {}_{14}^{28}Si \rightarrow {}_1^3S$	S
Sulfur	32	16	$_2^4He + {}_{16}^{32}S \rightarrow {}_1^3Ar$	Ar
Argon	36	18	$_2^4He + {}_{18}^{36}Ar \rightarrow {}_1^3Ca$	Ca
Calcium	40	20	$_2^4He + {}_{20}^{40}Ca \rightarrow {}_1^3Ti$	Ti
Titanium	44	22	$_2^4He + {}_{22}^{44}Ti \rightarrow {}_1^3Cr$	Cr

Activity 3

Beta decay 1. $_{15}^{32}P \rightarrow {}_{16}^{32}S + {}_{-1}^{0}e$

Alpha decay 2. $_{92}^{238}U \rightarrow {}_{90}^{234}Th + {}_{2}^{4}He$

Gamma decay 3. $_{90}^{234m}Th \rightarrow {}_{90}^{234}Th + \gamma$

Beta decay 4. $_{53}^{131}I \rightarrow {}_{54}^{131}Xe + {}_{-1}^{0}e$

Alpha decay 5. $_{88}^{226}Ra \rightarrow {}_{86}^{222}Rn + {}_{2}^{4}He$

Additional Activity

1. $_{92}^{235}U \rightarrow {}_{90}^{231}Th + {}_{2}^{4}He$, 2. $_{92}^{238}U \rightarrow {}_{93}^{238}Np + {}_{-1}^{0}e$, 3. $_{92}^{238}U \rightarrow {}_{92}^{235}U + \gamma$

4. $_{92}^{238}U \rightarrow {}_{90}^{234}Th + {}_{2}^{4}He$, 5. $_{6}^{14}C \rightarrow {}_{7}^{14}N + {}_{-1}^{0}e$, 6. $_{56}^{137}Ba \rightarrow {}_{56}^{137}Ba + \gamma$

References

Bayo-ang, Roly., Coronacion, Maria Lourdes., Jorda, Annamae., & Restubog, Anna Jamille. *Physical Science for Senior High School* (1st edition). Quezon City: Educational Resources Corporation, 2017.

For inquiries or feedback, please write or call:

Department of Education - Bureau of Learning Resources (DepEd-BLR)

Ground Floor, Bonifacio Bldg., DepEd Complex
Meralco Avenue, Pasig City, Philippines 1600

Telefax: (632) 8634-1072; 8634-1054; 8631-4985

Email Address: blr.lrqad@deped.gov.ph * blr.lrpd@deped.gov.ph