Senior High School

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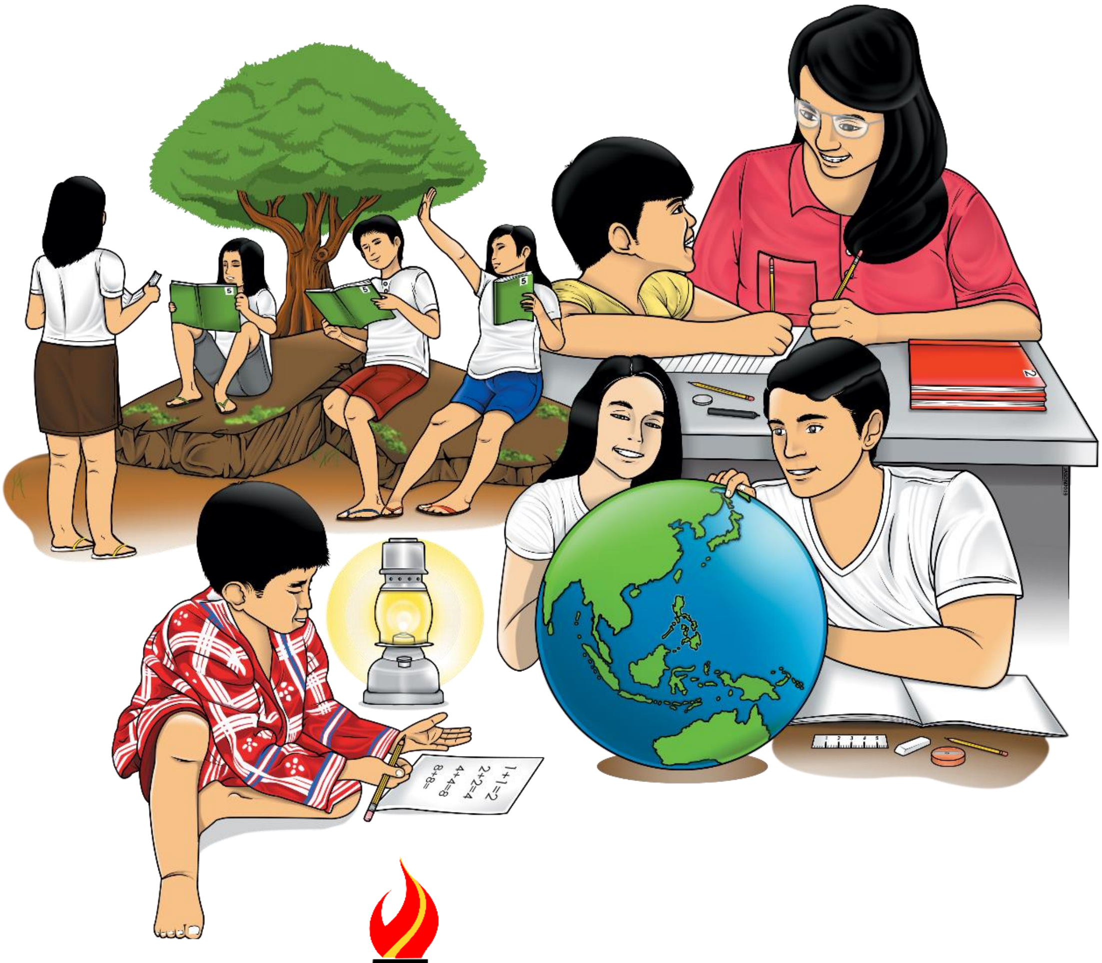
Physical Science

Quarter 1 – Module 2:
Concept of Atomic Number Led to the Synthesis of New Elements in the Laboratory



ALTERNATIVE DELIVERY MODE
ADM

Personal Development
Alternative Delivery Mode
Quarter 1 – Module 2: Concept of Atomic Number Led to the Synthesis of New Elements in the Laboratory
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Introductory Message

For the facilitator:

Welcome to the Physical Science Grade 11 Alternative Delivery Mode (ADM) Module on Concept of Atomic Number Led to the Synthesis of New Elements in the Laboratory!

This module was collaboratively designed, developed and reviewed by educators both from public and private institutions 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 into 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 Grade 11 Alternative Delivery Mode (ADM) Module on Concept of Atomic Number Led to the Synthesis of New Elements in the Laboratory!

The hand is one of the most symbolic 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 as a learner, you are 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 enabled 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 lesson to take. 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 sentence/paragraph to be filled in to process what you learned from the lesson.
What I Can Do	This section provides an activity which will help you apply your new knowledge or skill 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 deep understanding of the relevant competencies. You can do it!

What I Need to Know

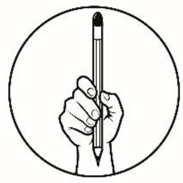
This module is especially designed for you. It will help you track the development of your understanding on how the concept of atomic number led to the synthesis of new elements in the laboratory.

To make learning easy for you, the module provides activities that will soon develop your curiosity on how the concept of atomic number led to the synthesis of new elements in the laboratory

The scope of this module permits it to be used in different learning situations. The language used recognizes the numerous vocabulary levels of students. The lessons are arranged to follow the standard sequence of the course. But the order in which you read them can be changed to correspond with the textbook you are now using.

After going through this module, you are expected to:

1. explain how the concept of atomic number led to the synthesis of new elements in the laboratory;
2. identify the different elements formed after the process of synthesis;
3. realize the importance of the atomic number in identifying the new elements identity in the periodic table.



What I Know

Directions: Choose the letter of the best answer. Write the chosen letter on a separate sheet of paper.

1. It is a device that is used to speed up the protons to overcome the repulsion between the protons and the target atomic nuclei by using magnetic and electrical fields.
    a. Spectroscopy　　c. Particle Accelerator
    b. Particle Decelerator　　d. Microscope

2. He created a classification of elements based on their atomic weight.
    a. Rutherford　　c. Millikan
    b. Dalton　　d. Mendeleev

3. It is a one-dimensional point which contains a huge mass in an infinitely small space.
    a. Nucleosynthesis　　c. Singularity
    b. Dilation　　d. R-process

4. He noticed that shooting electrons at elements caused them to release x-rays at unique frequencies.
    a. Mendeleev　　c. Moseley
    b. Millikan　　d. Serge

5. He synthesized element with atomic number 43 using a linear particle accelerator.
    a. Ernest Rutherford　　c. Dmitri Mendeleev
    b. Ernest Lawrence　　d. John Dalton

6. This is known as the origin and production of heavy elements.
    a. Stellar Nucleosynthesis　　c. R-Process
    b. Primordial Nucleosynthesis　　d. Supernova Nucleosynthesis

7. This is known as the origin of light elements.
    a. Stellar Nucleosynthesis　　c. R-Process
    b. Primordial Nucleosynthesis　　d. Supernova Nucleosynthesis

8. Process that can produce elements up to #83 - Bismuth.
   a. Nuclear Fission
   b. R-Process
   c. S Process
   d. S Process

9. This is also known as Nucleosynthesis.
   a. S Process
   b. R-Process
   c. Nuclear Fission
   d. Proton-Proton Reaction

10. This occurs in the main sequence of stars.
    a. Stellar Nucleosynthesis
    b. Primordial Nucleosynthesis
    c. R-Process
    d. Supernova Nucleosynthesis

11. It is also known as nuclear fusion and the formation of new nuclei actions in the early stages of development of the universe.
    a. Nucleosynthesis
    b. S-Process
    c. R-Process
    d. Singularity

12. In this process, there's a buildup of a VERY heavy isotope, then as beta-decays occur, you march up in atomic number and produce heavy product.
    a. S Process
    b. R-Process
    c. Nuclear Fission
    d. Proton-Proton Reaction

13. He successfully carried out a nuclear transmutation reaction, a process of transforming one element or isotope into another element.
    a. Chadwick
    b. Moseley
    c. Mendeleev
    d. Rutherford

14. It was created by bombardment of molybdenum by deuterons (heavy hydrogen, H12), by Emilio Segre and Carlo Perrier in 1937.
    a. Oxygen
    b. Helium
    c. Technetium
    d. Uranium

15. These are elements with atomic numbers beyond 103.
    a. Super Heavy Elements
    b. Gases Elements
    c. Lightest Element
    d. Halogens

Lesson 6 Physical Sciences: Concept of Atomic Number that Led to the Synthesis of New Elements in the Laboratory

Elements are made up of tiny particles, the neutron, proton and electron. H and Helium are the elements that exist in the early beginning. Early in the Big Bang, it was a tiny elementary particle. As the Universe expanded and cooled, there was a period of proton-proton chain reaction wherein protons were fuse into Helium. The Universe ran into a problem. Red giant cores get past this via the Triple-Alpha process, but the Universe expands right through this possibility and the density/temperature are quickly too low to synthesis any additional elements.

What's In

You learned earlier how all matter in the universe is made from tiny building blocks called atoms. All modern scientists accept the concept of the atom, but when the concept of the atom was first proposed about 2,500 years ago, ancient philosophers laughed at the idea. It has always been difficult to convince people of the existence of things that are too small to see. We will spend some time considering the evidence (observations) that convince scientists of the existence of atoms.

Do you have any idea how the different elements on the periodic table were formed, known and identified? Let's have a short review.

There is what we call Big Bang Theory that has some key stages: Singularity, Inflation, Nucleosynthesis and Recombination: Let us differentiate them. ***Singularity*** is a one-dimensional point which contains a huge mass in an infinitely small space, where density and gravity become infinite and space-time curves infinitely, and where the laws of physics as we know them cease to operate. The basic homogeneity in distribution of matter in the universe was established as a consequence of the first phase **of *inflation. Nucleosynthesis*** **was the** nuclear fusion and the formation of new nuclei ***a***ctions in the early stages of development of the universe. Recombination - the formation of the capture of free electrons by the cations in a plasma.

Notes to the Teacher

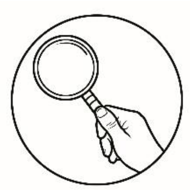
Let the student explore the process and the history on how elements form using the concept of atomic number.

What's New

Activity I.I Making Your Own Periodic Table

Make your own periodic table using the hypothetical elements that are given in the clues. Explain the word/s that will be formed if you arrange the symbols of the elements correctly.

a. P and Pr both have one electron each. Pr has a bigger atomic size.
b. Od, Ri, and E are in the same series as P, C, and I. In terms of atomic size, P is the biggest while C is the smallest. E is a metal while I is a non-metal. Od is smaller than Ri in atomic size.
c. O has a bigger atomic size than E in the same group. Y is also a bigger atom than C in the same group. R is more nonmetallic than Pe but more metallic than Ti.



What is It

Key Points

- The atomic number is the number of protons (positively charged particles) in an atom.
- Henry Gwyn-Jeffreys Moseley was an English physicist who demonstrated that the atomic number, the number of protons in an atom, determines most of the properties of an element.
- In 1919, Ernest Rutherford successfully carried out a nuclear transmutation reaction a process of transforming one element or isotope into another element.
- In 1925, there were four vacancies in the periodic table corresponding to the atomic numbers 43, 61, 85, and 87. Elements with atomic numbers 43 and 85 were synthesized using particle accelerators.
- A particle accelerator is a device that is used to speed up the protons to overcome the repulsion between the protons and the target atomic nuclei by using magnetic and electrical fields. It is used to synthesize new elements.

- Elements with atomic numbers greater than 92 (atomic number of uranium) are called transuranium elements They were discovered in the laboratory using nuclear reactors or particle accelerators.

Dmitri Mendeleev created a classification of elements based on their atomic weight. He found that organizing the elements at the time by their calculated weight demonstrated a periodic pattern of both physical and chemical properties, such as luster, physical state, reactivity to water, and others.

Activity 1.1 Making Your Own Periodic Table shows how theoretical elements where arrance accordiing to its atomic weight. For example, H has an atomic mass of 1.00794 amu, which makes hydrogen the lightest element on the periodic table. Hydrogen, H, was named by Laviosier and is the most abundant element on the periodic table. It is followed by He, Li, Be and so on and so fort because atomic weight is used to arrange elements from lightest to heaviest.

Hello there, let me help you about how elements form with the atomic concept.

By the way, He is Henry Moseley. He was an English physicist whose experiment demonstrated that the major properties of an element are determined by the atomic number, not by the atomic weight, and firmly established the relationship between atomic number and the charge of the atomic nucleus.

Henry Moseley was a researcher at Rutherford's laboratory.

In 1913, Moseley used Rutherford's work to advance the understanding of the elements and solve the problem with Mendeleev's periodic table.

Moseley noticed that shooting electrons at elements caused them to release x-rays at unique frequencies. He also noticed that the frequency increased by a certain amount when the "positive charge" of the chosen element was higher.

By arranging the elements according to the square root of the frequency they emitted, he was able to draw out an arrangement of elements that more correctly predicted periodic trends.

Mention the experimental evidence he gave to an existing hypothesis: that the elements' atomic number, or place in the periodic table, was uniquely tied to their "positive charge", or the number of protons they had. This discovery allowed for a better arrangement of the periodic table, and predicted elements that were not yet discovered. His method of identifying elements by shooting electrons and looking at x-rays became a very useful tool in characterizing elements, and is now called **x-ray spectroscopy.**

He used X-ray spectroscopy to determine the atomic number of an element. He bombarded a beam of electrons to different elements and measured their X-ray spectral lines. His results clearly showed that frequency of the X-rays given off by an element was mathematically related to the position of that element in the Periodic table. The frequency is proportional to the charge of the nucleus, or the atomic number.

When the elements were arranged according to their atomic numbers, there were four gaps in the table. These gaps corresponded to the atomic numbers 43, 61, 85, and 87. These elements were later synthesized in the laboratory through nuclear transmutations.

Discovery of Nuclear Transmutation

In 1919, Ernest Rutherford successfully carried out a nuclear transmutation reaction — a reaction involving the transformation of one element or isotope into another element. The first nuclide to be prepared by artificial means was an isotope of oxygen, 17O. It was made by Ernest Rutherford in 1919 by bombarding nitrogen atoms with α particles:

$$^{14}_{7}\mathrm{N} + ^{4}_{2}\alpha \rightarrow ^{17}_{8}\mathrm{O} + ^{1}_{1}\mathrm{H}$$

However, both alpha particles and atomic nuclei are positively charged, so they tend to repel each other. Therefore, instead of using fast-moving alpha particles in synthesizing new elements, atomic nuclei are often bombarded with neutrons (neutral particles) in particle accelerators.

James Chadwick discovered the neutron in 1932, as a previously unknown neutral particle produced along with 12C by the nuclear reaction between 9Be and 4He:

$$^{9}_{4}Be + ^{4}_{2}He \rightarrow ^{12}_{6}C + ^{1}_{0}n$$

The first element to be prepared that does not occur naturally on the earth, technetium, was created by bombardment of molybdenum by deuterons (heavy hydrogen, H12), by Emilio Segre and Carlo Perrier in 1937:

$$^{2}_{1}H + ^{97}_{42}Mo \rightarrow 2\ ^{1}_{0}n + ^{97}_{43}Tc$$

The first controlled nuclear chain reaction was carried out in a reactor at the University of Chicago in 1942. One of the many reactions involved was:

$$^{235}_{92}U + \ ^{1}_{0}n \rightarrow \ ^{87}_{35}Br + \ ^{146}_{57}La + 3^{1}_{0}n$$

The Discovery of the Missing Elements

Recall that in 1925, there were four vacancies in the periodic table corresponding to the atomic numbers 43, 61, 85, and 87. Two of these elements were synthesized in the laboratory using particle accelerators. A particle accelerator is a device that is used to speed up the protons to overcome the repulsion between the protons and the target atomic nuclei by using magnetic and electrical fields. It is used to synthesize new elements. In 1937, American physicist **Ernest Lawrence** synthesized element with atomic number 43 using a linear particle accelerator. He bombarded molybdenum (Z=42) with fast-moving neutrons. The newly synthesized element was named Technetium (Tc) after the Greek word "technêtos" meaning “artificial.” Tc was the first man-made element.

The bombarding of Mo with deuteron formed technicium which is the first artificially made element.

$$^{97}_{42}Mo \ + ^{2}_{1}H \rightarrow \ ^{97}_{43}Tc \ \ + \ ^{1}_{0}n$$

In 1940, Dale Corson, K. Mackenzie, and Emilio Segre discovered element with atomic number 85. They bombarded atoms of bismuth (Z=83) with fast-moving alpha particles in a cyclotron. A cyclotron is a particle accelerator that uses alternating electric field to accelerate particles that move in a spiral path in the presence of a magnetic field. Element-85 was named astatine from the Greek word “astatos” meaning unstable.

The two other elements with atomic numbers 61 and 87 were discovered through studies in radioactivity. Element-61 (Promethium) was discovered as a decay product of the fission of uranium while element-87 (Francium) was discovered as a breakdown product of uranium.

The Synthesis of the Elements

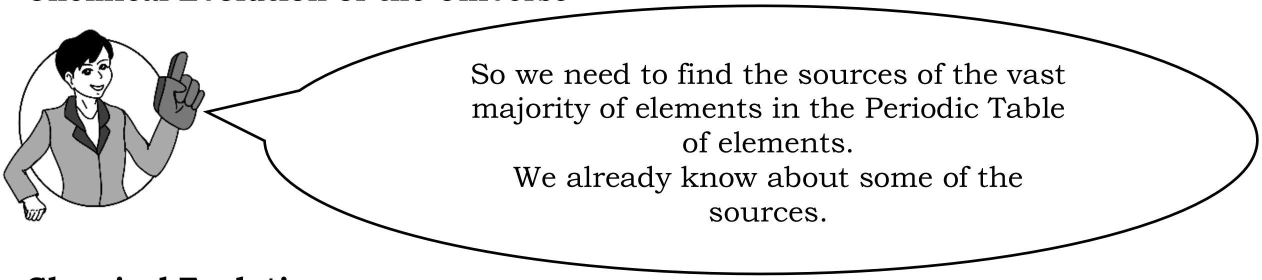
The invention of the device called cyclotron paved the way for transmuting one element into another artificially. The high-energy particles that are produced from the cyclotron upon hitting heavy target nuclei produce heavier nuclei.

The Universe ran into the Be problem. Red giant cores get past this via the Triple-Alpha process, but the Universe expands right through this possibility and the density/temperature are quickly too low to synthesis any additional elements.

Big Bang Nucleosynthesis

- The oldest stars in the Galaxy are deficient in the abundance of elements heavier than Helium (but show the predicted amount of He)
- The current record holder has Fe/H about 130,000 times smaller than the solar value.
- Not quite down to Big Bang abundances, but we are getting pretty close and still looking.

Chemical Evolution of the Universe



Chemical Evolution

- Low-mass stars synthesize `new' He, C, O during the main-sequence, RGB, HB and AGB phases.
- These freshly minted elements are brought to the surface via convection and redistributed via stellar winds and planetary nebulae into the interstellar medium to be incorporated into later generations of stars.

Chemical Evolution II

- For more massive stars, `equilibrium' fusion reactions produce elements all the way up to Fe.
- Freshly made elements are delivered via stellar winds or, sometimes more spectacularly via supernova explosions

Chemical Evolution III

What about the trans-Fe elements?

- Equilibrium fusion reactions of light elements don't proceed past Fe because of Fe's location at the peak of the curve of binding energy.
- However, in certain circumstances, supernovae for example, non-equilibrium reactions can build elements beyond Fe in the Periodic Table. Many of these are radioactive, but some are stable.

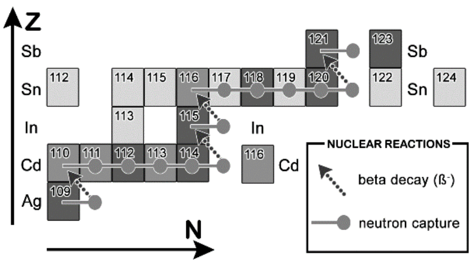
Neutron Capture Elements

- There are two principle paths to building the elements heavier than Fe. Both use the addition of neutrons to existing `seed' nuclei (neutrons have no charge so are much easier to add to positively-charged nuclei).

S-process (slow addition of neutrons)
R-process (rapid addition of neutrons)

The S-process

- The S-process stands for the Slow addition of neutrons to nuclei. The addition of a no produces heavier isotope of a particular element. However, if an electron is emitted (this is called beta-decay), the nucleus moves one step up the periodic table.
- `Slow' here means that rate of no captures is low compared to the beta-decay rate.
- It really is slow. Sometimes 100's of years go by between neutron captures.



The s-process acting in the range from Ag to Sb.

$$Fe^{56} + n^o \rightarrow Fe^{57}$$
$$Fe^{57} \rightarrow Co^{57} + e^-$$

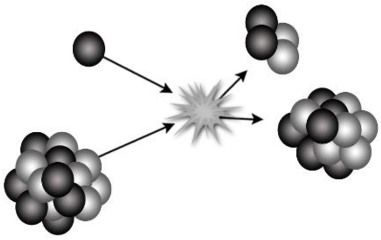
Here a neutron changed into a proton by emitting an electron

- The S-process can produce elements up to #83 - Bismuth. There are peaks in the Solar System abundance of heavy elements at 38Sr, 56Ba and 82Pb. These are easily understood in the context of the S-process and `magic' numbers of neutrons.
- The site of the S-process is AGB start during and between shell flashes. The no source is a by-product of C_{13}+He_4 -> O_{16}
- 43Tc is an s-process nucleus and proof that it is in operation in AGB stars.

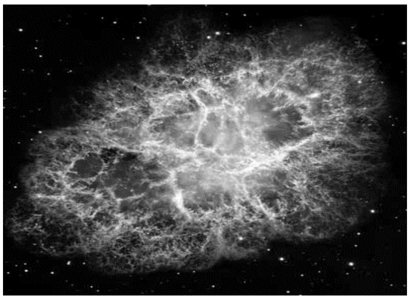
The R-process

- The R-process is the Rapid addition of neutrons to existing nuclei. Rapid here means that many neutrons are added before a beta-decay occurs.
- First build up a VERY heavy isotope, then, as beta-decays occur, you march up in atomic number and produce the REALLY HEAVY STUFF.
- For this to happen, a big burst of neutrons is needed. The most promising place with the right conditions is in a SNII explosion right above the collapsed core.

- We see an overabundance of R-process elements in the oldest stars. As the early chemical enrichment of the Galaxy was through SNII, this is evidence of SNII as the source of r-process elements.
- If we look at the Crab Nebula or other SNII remnants we don't see r-process elements.
- We DO see regions of enhanced O, Si, Ne and He which appear to reflect the `onion skin' structure of the massive star progenitor.



1Diagram (How R-Process Occur)



Crab Nebula
https://www.nasa.gov/mission_pages/hubble/multimedia/crab_nebula.html

The Transuranic Elements

In the 1930s, the heaviest element known was uranium, with an atomic number 92. Early in 1940, Edwin McMillan proved that an element having an atomic number 93could be created. He used a particle accelerator to bombard uranium with neutrons and created an element with an atomic number 93 which he named neptunium.

Transuranic elements are synthetic elements with atomic numbers higher than that of Uranium (Z = 92).

$$^{238}_{92}U + ^{1}_{0}n \rightarrow \ ^{239}_{93}Np + ^{\ 0}_{-1}\beta$$

Plutonium (Z = 94)

$$^{238}_{92}U + ^{2}_{1}H \rightarrow \ ^{239}_{93}Np + 2^{1}_{0}n$$

$$^{238}_{93}Np \rightarrow \ ^{239}_{94}Np^{+1} + ^{\ 0}_{-1}\beta$$

At the end of 1940, element-94 was synthesized by Seaborg, McMillan, Kennedy, and Wahl. They bombarded uranium with deuterons (particles composed of a proton and a neutron) in a cyclotron. Element-94 was named plutonium.

Elements with atomic numbers greater than 92 (atomic number of uranium) are called transuranium elements. Hence, neptunium and plutonium are both transuranium elements. They are unstable and decay radioactively into other elements. All these elements were discovered in the laboratory as artificially generated synthetic elements. They are prepared using nuclear reactors or particle accelerators. In the next lesson, you will learn the nuclear reactions involved in the synthesis of these transuranium elements.

Stellar nucleosynthesis

This is the process by which elements are created within stars by combining the protons and neutrons together from the nuclei of lighter elements. Fusion inside stars transforms hydrogen into helium, heat, and radiation. Heavier elements are created in different types of stars as they die or explode.

The Superheavy Elements

Superheavy elements are elements with atomic numbers beyond 103. These are produced by bombarding heavy nuclear targets with accelerated heavy projectiles.

Bohrium (Z = 107) – projectile used was Cr

$$^{209}_{83}Bi + ^{54}_{24}Cr \rightarrow \ ^{261}_{107}Bh + 2^{1}_{0}n$$

Following are the equations of several nuclear reactions that have important roles in the history of nuclear chemistry:

• The first naturally occurring unstable element that was isolated, polonium, was discovered by the Polish scientist Marie Curie and her husband Pierre in 1898. It decays, emitting particles:

$$^{212}_{84}Po \rightarrow \ ^{208}_{82}Pb + ^{4}_{2}He$$

What's More

Activity 1.1 Write the nuclear reactions involved in the synthesis of each of the following new elements:

a. Curium (Z = 96) was formed by reacting Pu – 239 with alpha particles 42He. It has a half-life of 162 days.
b. Mendelevium (Z = 101) was formed by reacting En-253 with alpha particles.
c. Meitnerium (Z = 109) was formed by cold fusion which involves the combination of Bi and Fe nuclides at ordinary temperature

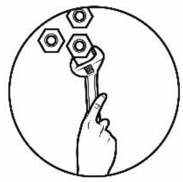
What I Have Learned

Why do scientists study and synthesize new transuranium elements in the laboratory? What are the uses of these elements?

Create a timeline using illustrations and text showing on how elements form with the concept of atomic number.

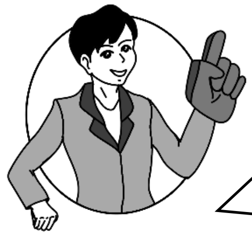
Timeline Rubric

Category	10 points	7 points	5 points	3 points
Content/ Facts	Facts were accurate for all events reported on the timeline	Facts were accurate for almost all events reported on the timeline.	Facts were accurate for most (~75%) of the events reported on the timeline.	Facts were often inaccurat e for events reported on the timeline.
Graphics	All graphics are effective and balanced with text use.	All graphics are effective, but there appear to be too few or too many.	Some graphics are effective and their use is balanced with text use.	Several graphics are not effective.
Readability	The overall appearance of the timeline is pleasing and easy to read.	The overall appearance of the timeline is somewhat pleasing and easy to read.	The timeline is relatively readable.	The timeline is difficult to read.
Requirements	The timeline contained 10 events related to the topic being studied.	The timeline contained at least 8-9 events related to the topic being studied.	The timeline contained at least 6-7 events related to the topic being studied.	The timeline contained fewer than 5 events.



What I Can Do

Short Essay (maximum of 3 sentences)



1. Dmitri Mendeleev is often regarded as the Father of the Periodic Table. Would you say that Henry Moseley deserves the recognition more than him?
2. Explain why the atomic number is called the "fingerprint" of elements.
3. How would you relate alchemy to synthesis of new elements?

Assessment

Directions: Choose the letter of the best answer. Write the chosen letter on a separate sheet of paper.

1. He successfully carried out a nuclear transmutation reaction, a process of transforming one element or isotope into another element.
   a. Chadwick c. Mendeleev
   b. Moseley d. Rutherford

2. This is also known as Nucleosynthesis.
   a. S Process c. Nuclear Fission
   b. R-Process d. Proton-Proton Reaction

3. This is known as the origin and production of heavy elements.
   a. Stellar Nucleosynthesis c. R-Process
   b. Primordial Nucleosynthesis d. Supernova Nucleosynthesis

4. It was created by bombardment of molybdenum by deuterons (heavy hydrogen, H12), by Emilio Segre and Carlo Perrier in 1937.
   a. Oxygen c. Technetium
   b. Helium d. Uranium
   c.
5. Process that can produce elements up to #83 - Bismuth.

a. Nuclear Fission
b. R-Process
c. S Process
d. S Process

6. This is known as the origin of light elements.
   a. Stellar Nucleosynthesis
   b. Primordial Nucleosynthesis
   c. R-Process
   d. Supernova Nucleosynthesis

7. It is also known as nuclear fusion and the formation of new nuclei actions in the early stages of development of the universe.
   a. Nucleosynthesis
   b. S-Process
   c. R-Process
   d. Singularity

8. In this process there's a buildup of a VERY heavy isotope, then as beta-decays occur, you march up in atomic number and produce heavy product.
   a. S Process
   b. R-Process
   c. Nuclear Fission
   d. Proton-Proton Reaction

9. These are elements with atomic numbers beyond 103.
   a. SuperHevy Elements
   b. Gases Elements
   c. Lightest Element
   d. Halogens

10. This occurs in the main sequence of stars.
    a. Stellar Nucleosynthesis
    b. Primordial Nucleosynthesis
    c. R-Process
    d. Supernova Nucleosynthesis

11. It is a device that is used to speed up the protons to overcome the repulsion between the protons and the target atomic nuclei by using magnetic and electrical fields.
    a. Spectroscopy
    b. Particle Decelerator
    c. Particle Accelerator
    d. Microscope

12. He created a classification of elements based on their atomic weight.
    a. Rutherford
    b. Dalton
    c. Millikan
    d. Mendeleev

13. It is a one-dimensional point which contains a huge mass in an infinitely small space.
    a. Nucleosynthesis
    b. Dilation
    c. Singularity
    d. R-process

14. He noticed that shooting electrons at elements caused them to release x-rays at unique frequencies.
    a. Mendeleev
    b. Millikan
    c. Moseley
    d. Serge

15. He synthesized element with atomic number 43 using a linear particle accelerator.

a. Ernest Rutherford
b. Ernest Lawrence
c. Dmitri Mendeleev
d. John Dalton

Additional Activities

Research on the latest instruments used in preparing new elements in the laboratory. What were the instruments used in preparing the newest four elements, nihonium, moscovium, tennessine, and oganesson?

Answer Key

What I Know

1. c
2. d
3. c
4. c
5. b
6. a
7. b
8. c
9. c
10. a
11. a
12. b
13. d
14. c
15. a

What's More

a. 23994Pu + 42He —> 24296Cm+ 10n Cm is named after Marie and Pierre Curie who had done extensive research on natural radioactivity.

b. 25399 En + 42He —> 256101Mv + 10n Mv is named after Dmitri Mendeleev.

c. 20983Bi + 5826Fe—> 266109Mt + 10n

Assessment

1. d
2. c
3. a
4. c
5. c
6. b
7. a
8. b
9. a
10. a
11. c
12. d
13. c
14. c
15. b

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