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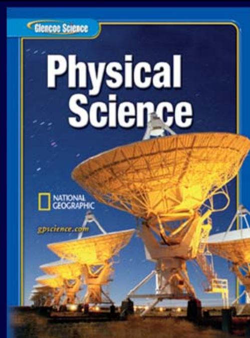


Table of Contents

18

Unit 4: The Nature of Matter

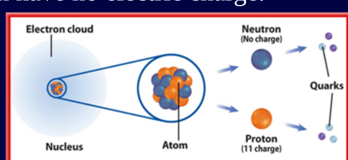
Chapter 18: Radioactivity and Nuclear Reactions

Radioactivity

18.1

The Nucleus

- Recall that atoms are composed of protons, neutrons, and electrons.
- The nucleus of an atom contains the protons, which have a positive charge, and neutrons, which have no electric charge.



Radioactivity

18.1

The Nucleus

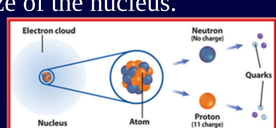
- An electron has a charge that is equal but opposite to a proton's charge.
- Atoms usually contain the same number of protons as electrons.
- Negatively charged electrons are electrically attracted to the positively charged nucleus and swarm around it.

Radioactivity

18.1

Protons and Neutrons in the Nucleus

- Protons and neutrons are packed together tightly in a nucleus.
- The region outside the nucleus in which the electrons are located is large compared to the size of the nucleus.



Radioactivity

18.1

Protons and Neutrons in the Nucleus

- If an atom were enlarged so that it was 1 km in diameter, its nucleus would have a diameter of only a few centimeters.
- But the nucleus contains almost all the mass of the atom.

Radioactivity

18.1

The Strong Force

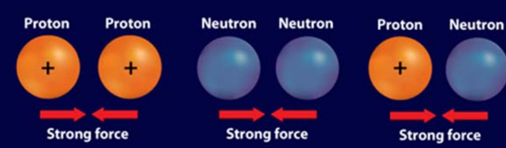
- How do you suppose protons and neutrons are held together so lightly in the nucleus?
- Another force, called the **strong force**, causes protons and neutrons to be attracted to each other.

Radioactivity

18.1

The Strong Force

- The strong force is one of the four basic forces in nature and is about 100 times stronger than the electric force.

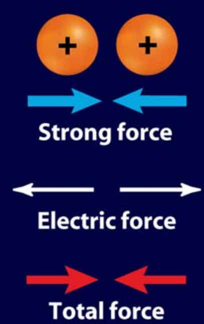


Radioactivity

18.1

The Strong Force

- Protons and neutrons have to be close together, like they are in the nucleus, to be attracted by the strong force.

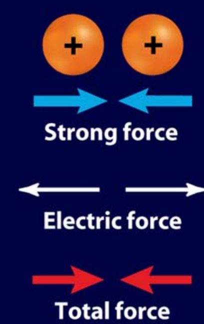


Radioactivity

18.1

The Strong Force

- The strong force is a short-range force that quickly becomes extremely weak as protons and neutrons get farther apart.



Radioactivity

18.1

The Strong Force

- The electric force is a long-range force, so protons that are far apart still are repelled by the electric force.

Radioactivity

18.1

Attractions and Repulsion

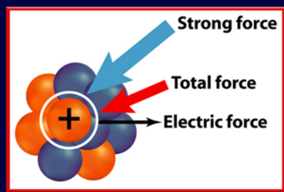
- Some atoms, such as uranium, have many protons and neutrons in their nuclei.
- These nuclei are held together less tightly than nuclei containing only a few protons and neutrons.

Radioactivity

18.1

Attractions and Repulsion

- If a nucleus has only a few protons and neutrons, they are all close enough together to be attracted to each other by the strong force.

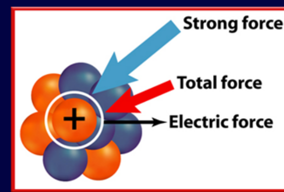


Radioactivity

18.1

Attractions and Repulsion

- Because only a few protons are in the nucleus, the total electric force causing protons to repel each other is small.

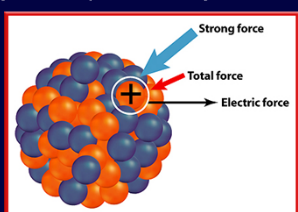


Radioactivity

18.1

Forces in a Large Nucleus

- If nuclei have many protons and neutrons, each proton or neutron is attracted to only a few neighbors by the strong force.



Radioactivity

18.1

Forces in a Large Nucleus

- Because only the closest protons and neutrons attract each other in a large nucleus, the strong force holding them together is about the same as in a small nucleus.
- All the protons in a large nucleus exert a repulsive electric force on each other.
- Thus, the electric repulsive force on a proton in a large nucleus is larger than it would be in a small nucleus.

Radioactivity

18.1

Radioactivity

- When the strong force is not large enough to hold a nucleus together tightly, the nucleus can decay and give off matter and energy.
- This process of nuclear decay is called **radioactivity**.

Radioactivity

18.1

Radioactivity

- All nuclei that contain more than 83 protons are radioactive.
- However, many other nuclei that contain fewer than 83 protons also are radioactive.

Radioactivity

18.1

Radioactivity

- Almost all elements with more than 92 protons don't exist naturally on Earth.
- They have been produced only in laboratories and are called synthetic elements.
- These synthetic elements are unstable, and decay soon after they are created.

Radioactivity

18.1

Isotopes

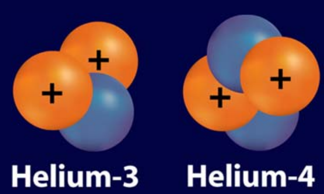
- Nuclei that have the same number of protons but different numbers of neutrons are called isotopes.
- The atoms of all isotopes of an element have the same number of electrons, and have the same chemical properties.

Radioactivity

18.1

Isotopes

- These two isotopes of helium each have the same number of protons, but different numbers of neutrons.



Radioactivity

18.1

Stable and Unstable Nuclei

- In less massive elements, an isotope is stable if the ratio is about 1 to 1.
- Isotopes of the heavier elements are stable when the ratio of neutrons to protons is about 3 to 2.

Radioactivity

18.1

Stable and Unstable Nuclei

- The nuclei of any isotopes that differ much from these ratios are unstable, whether the elements are light or heavy.
- Nuclei with too many or too few neutrons compared to the number of protons are radioactive.

Radioactivity

18.1

Nucleus Numbers

- The number of protons in a nucleus is called the atomic number.
- Because the mass of all the protons and neutrons in a nucleus is nearly the same as the mass of the atom, the number of protons and neutrons is called the mass number.

Radioactivity

18.1

Nucleus Numbers

- A nucleus can be represented by a symbol that includes its atomic number, mass number, and the symbol of the element it belongs to.
- The symbol for the nucleus of the stable isotope of carbon is shown:

mass number → $^{12}_{6}C$ ← element symbol
atomic number →

CHAPTER RESOURCES END

Radioactivity

18.1

Nucleus Numbers

- This isotope is called carbon-12.
- The number of neutrons in the nucleus is the mass number minus the atomic number.
- So the number of neutrons in the carbon-12 nucleus is 12 – 6 = 6.

CHAPTER RESOURCES END

Radioactivity

18.1

The Discovery of Radioactivity

- In 1896, Henri Becquerel left uranium salt in a desk drawer with a photographic plate.
- Later, when he developed the plate, he found an outline of the clumps of the uranium salt.
- He hypothesized that the uranium salt had emitted some unknown invisible rays, or radiation, that had darkened the film.

CHAPTER RESOURCES END

Radioactivity

18.1

The Discovery of Radioactivity

- Two years after Becquerel's discovery, Marie and Pierre Curie discovered two new elements, polonium and radium, that also were radioactive.
- After more than three years, they were able to obtain about 0.1 g of radium from several tons of pitchblende.

CHAPTER RESOURCES END

Radioactivity

18.1

The Discovery of Radioactivity

- Years of additional processing gradually produced more radium that was made available to other researchers all over the world.

CHAPTER RESOURCES END

Section Check

18.1

Question 1

The total amount of charge in a nucleus is determined by __________.

A. atomic number
B. molecular weight
C. number of neutrons
D. number of photons

CHAPTER RESOURCES END

Section Check

18.1

Answer

The answer is A. The total amount of charge is determined by the number of protons, also called the atomic number.

Section Check

18.1

Question 2

Compare the strong force to the electric force.

Answer

The strong force is a short-range force that causes the protons and neutrons in a nucleus to be attracted to each other. The electric force is a long-range force that causes protons to repel each other.

Section Check

18.1

Question 3

What is radioactivity?

Answer

Radioactivity is the process of nuclear decay, in which the nucleus gives off matter and energy.

Nuclear Decay

18.2

Nuclear Radiation

- When an unstable nucleus decays, particles and energy called nuclear radiation are emitted from it.
- The three types of nuclear radiation are alpha, beta (BAY tuh), and gamma radiation.
- Alpha and beta radiation are particles. Gamma radiation is an electromagnetic wave.

Nuclear Decay

18.2

Alpha Particles

- When alpha radiation occurs, an **alpha particle**—made of two protons and two neutrons is emitted from the decaying nucleus.

Alpha Particles

Symbol	${}^{4}_{2}He$
Mass	4
Charge	+2

Nuclear Decay

18.2

Alpha Particles

- Notice that the alpha particle and its symbol is the same as a helium nucleus, ${}^{4}_{2}He$.
- An alpha particle has an electric charge of +2 and an atomic mass of 4.

Alpha Particles

Symbol	${}^{4}_{2}He$
Mass	4
Charge	+2

Alpha Particles

- Compared to beta and gamma radiation, alpha particles are much more massive. They also have the most electric charge.
- When alpha particles pass through matter, they exert an electric force on the electrons in atoms in their path.

CHAPTER RESOURCES END

Alpha Particles

- This force pulls electrons away from atoms and leaves behind charged ions.
- Alpha particles are the least penetrating form of nuclear radiation.
- Alpha particles can be stopped by a sheet of paper.

CHAPTER RESOURCES END

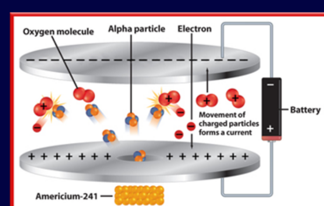
Damage from Alpha Particles

- Alpha particles can be dangerous if they are released by radioactive atoms inside the human body.
- Biological molecules inside your body are large and easily damaged.
- Damage from alpha particles can cause cells not to function properly, leading to illness and disease.

CHAPTER RESOURCES END

Smoke Detectors

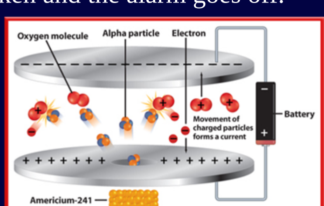
- Some smoke detectors give off alpha particles that ionize the surrounding air.



CHAPTER RESOURCES END

Smoke Detectors

- If smoke particles enter the ionized air, they will absorb the ions and electrons. The circuit is broken and the alarm goes off.



CHAPTER RESOURCES END

Transmutation

- **Transmutation** is the process of changing one element to another through nuclear decay.
- In alpha decay, two protons and two neutrons are lost from the nucleus.

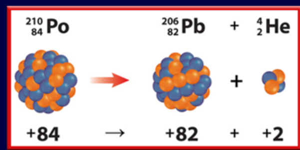
CHAPTER RESOURCES END

Nuclear Decay

18.2

Transmutation

- The new element has an atomic number two less than that of the original element.
- The mass number of the new element is four less than the original element.
- In this transmutation, polonium emits an alpha particle and changes into lead.



Nuclear Decay

18.2

Beta Particles

- A second type of radioactive decay is called beta decay.
- Sometimes in an unstable nucleus a neutron decays into a proton and emits an electron.

Beta Particles

Symbol	$^{0}_{-1}e$
Mass	0.0005
Charge	–1

Nuclear Decay

18.2

Beta Particles

- The electron is emitted from the nucleus and is called a **beta particle**.
- Beta decay is caused by another basic force called the weak force.

Beta Particles

Symbol	$^{0}_{-1}e$
Mass	0.0005
Charge	–1

Nuclear Decay

18.2

Beta Particles

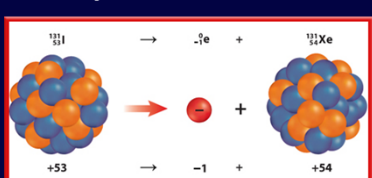
- Because the atom now has one more proton, it becomes the element with an atomic number one greater than that of the original element.
- However, because the total number of protons and neutrons does not change during beta decay, the mass number of the new element is the same as that of the original element.

Nuclear Decay

18.2

Beta Particles

- Nuclei that emit beta particles undergo transmutation. In beta decay shown here, iodine changes to xenon.



Nuclear Decay

18.2

Damage from Beta Particles

- Beta particles are much faster and more penetrating than alpha particles.
- Beta particles can damage cells when they are emitted by radioactive nuclei inside the human body.

Nuclear Decay

18.2

Gamma Rays

- The most penetrating form of nuclear radiation is gamma radiation.
- **Gamma rays** are electromagnetic waves with the highest frequencies and the shortest wavelengths in the electromagnetic spectrum.

Nuclear Decay

18.2

Gamma Rays

- They have no mass and no charge and travel at the speed of light.
- The properties of gamma rays are summarized in the table.

Gamma Rays

Symbol	γ
Mass	0
Charge	0

Nuclear Decay

18.2

Gamma Rays

- Thick blocks of dense materials, such as lead and concrete, are required to stop gamma rays.
- However, gamma rays cause less damage to biological molecules as they pass through living tissue.

Nuclear Decay

18.2

Radioactive Half-Life

- Some radioisotopes decay to stable atoms in less than a second.
- However, the nuclei of certain radioactive isotopes require millions of years to decay.
- A measure of the time required by the nuclei of an isotope to decay is called the half-life.

Nuclear Decay

18.2

Radioactive Half-Life

- The **half-life** of a radioactive isotope is the amount of time it takes for half the nuclei in a sample of the isotope to decay.
- The nucleus left after the isotope decays is called the daughter nucleus.

Nuclear Decay

18.2

Radioactive Half-Life

- Half-lives vary widely among the radioactive isotopes.
- The half-lives of some radioactive elements are listed in the table.

Sample Half-Lives

Isotope	Half-Life
$^{3}_{1}H$	12.3 years
$^{212}_{82}Pb$	10.6 hr
$^{14}_{6}C$	5,730 years
$^{211}_{84}Po$	0.5 s
$^{235}_{92}U$	7.04×10^{8} years
$^{131}_{53}I$	8.04 days

Nuclear Decay

18.2

Radioactive Dating

- Some geologists, biologists, and archaeologists, among others, are interested in the ages of rocks and fossils found on Earth.
- The ages of these materials can be determined using radioactive isotopes and their half-lives.

Nuclear Decay

18.2

Radioactive Dating

- The number of half-lives is the amount of time that has passed since the isotope began to decay.
- It is also usually the amount of time that has passed since the object was formed, or the age of the object.

Nuclear Decay

18.2

Carbon Dating

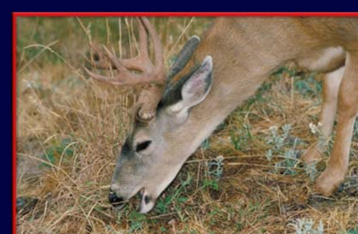
- Carbon-14 has a half-life of 5,730 years and is found in molecules such as carbon dioxide.
- Plants use carbon dioxide when they make food, so all plants contain carbon-14.

Nuclear Decay

18.2

Carbon Dating

- When animals eat plants, carbon-14 is added to their bodies.



Nuclear Decay

18.2

Carbon Dating

- The ratio of the number of carbon-14 atoms to the number of carbon-12 atoms in the organism remains nearly constant.
- When an organism dies, its carbon-14 atoms decay without being replaced.
- The ratio of carbon-14 to carbon-12 then decreases with time.

Nuclear Decay

18.2

Carbon Dating

- By measuring this ratio, the age of an organism's remains can be estimated.
- Only material from plants and animals that lived with the past 50,000 years contains enough carbon-14 to be measured.

18.2

Uranium Dating

- Some rocks contain uranium, which has two radioactive isotopes with long half-lives.
- Each of these uranium isotopes decays into a different isotope of lead.

18.2

Uranium Dating

- The amount of these uranium isotopes and their daughter nuclei are measured.
- From the ratios of these amounts, the number of half-lives since the rock was formed can be calculated.

18.2

Question 1

What is an alpha particle composed of?

18.2

Answer

An alpha particle is made of two protons and two neutrons.

Alpha Particles

Symbol	$^{4}_{2}He$
Mass	4
Charge	+2

18.2

Question 2

Which nuclear radiation particle is the most massive?

A. alpha
B. beta
C. gamma
D. isotope

18.2

Answer

The answer is A. Alpha particles are more massive than either beta particles or gamma radiation, which is an electromagnetic wave.

Section Check

18.2

Question 3

After how many half-lives will there be one thirty-second the original sample of radioactive nuclei?

A. 5
B. 4
C. 3
D. 2

Section Check

18.2

Answer

The answer is D. After two half-lives, there is one-fourth the original sample; after three half-lives there is one-eighth.

Detecting Radioactivity

18.3

Radiation Detectors

- Because you can't see or feel alpha particles, beta particles, or gamma rays, you must use instruments to detect their presence.
- Some tools that are used to detect radioactivity rely on the fact that radiation forms ions in the matter it passes through.

Detecting Radioactivity

18.3

Cloud Chambers

- A **cloud chamber** can be used to detect alpha or beta particle radiation.
- A cloud chamber is filled with water or ethanol vapor.
- When a radioactive sample is placed in the cloud chamber, it gives off charged alpha or beta particles that travel through the water or ethanol vapor.

Detecting Radioactivity

18.3

Cloud Chambers

- As each charged particle travels through the chamber, it knocks electrons off the atoms in the air, creating ions.
- Beta particles leave long, thin trails, and alpha particles leave shorter, thicker trails.

Detecting Radioactivity

18.3

Bubble Chambers

- A **bubble chamber** holds a superheated liquid, which doesn't boil because the pressure in the chamber is high.
- When a moving particle leaves ions behind, the liquid boils along the trail.
- The path shows up as tracks of bubbles.

Detecting Radioactivity

18.3

Electroscopes

- When an electroscope is given a negative charge, its leaves repel each other and spread apart.
- They will remain apart until their extra electrons have somewhere to go and discharge the electroscope.

CHAPTER RESOURCES END

Detecting Radioactivity

18.3

Electroscopes

- Nuclear radiation moving through the air can remove electrons from some molecules in air and cause other molecules in air to gain electrons.

CHAPTER RESOURCES END

Detecting Radioactivity

18.3

Electroscopes

- When this occurs near the leaves of the electroscope, some positively charged molecules in the air can come in contact with the electroscope and attract the electrons from the leaves.
- As these negatively charged leaves lose their charges, they move together.

CHAPTER RESOURCES END

Detecting Radioactivity

18.3

Measuring Radiation

- Large doses of radiation can be harmful to living tissue.
- A **Geiger counter** is a device that measures the amount of radiation by producing an electric current when it detects a charged particle.

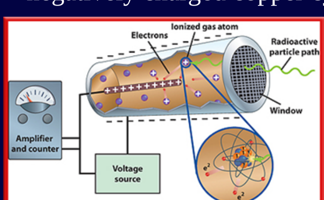
CHAPTER RESOURCES END

Detecting Radioactivity

18.3

Geiger Counter

- A Geiger counter has a tube with a positively charged wire running through the center of a negatively charged copper cylinder.



- This tube is filled with gas at a low pressure.

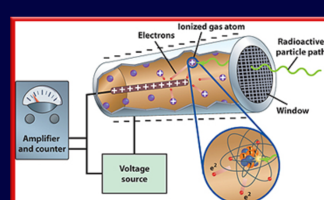
CHAPTER RESOURCES END

Detecting Radioactivity

18.3

Geiger Counter

- When radiation enters the tube at one end, it knocks electrons from the atoms of the gas.



- Electrons that are stripped off gas molecules in a Geiger counter move to a positively charged wire in the device.

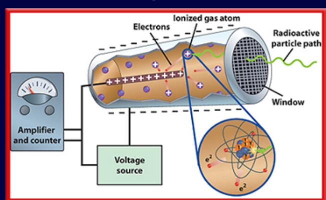
CHAPTER RESOURCES END

Detecting Radioactivity

18.3

Geiger Counter

- This causes current to flow in the wire.
- The current then is used to produce a click or a flash of light.



CHAPTER RESOURCES END

Detecting Radioactivity

18.3

Background Radiation

- Background radiation, is not produced by humans, instead it is low-level radiation emitted mainly by naturally occurring radioactive isotopes found in Earth's rocks, soils, and atmosphere.
- Traces of naturally occurring radioactive isotopes are found in the food, water, and air consumed by all animals and plants.

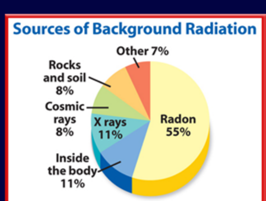
CHAPTER RESOURCES END

Detecting Radioactivity

18.3

Source of Background Radiation

- Background radiation comes from several sources.



- The largest source comes from the decay of radon gas.
- Radon gas can seep into houses and basements from the surrounding soil and rocks.

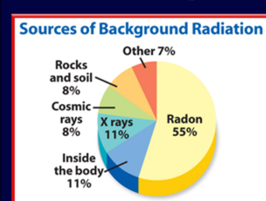
CHAPTER RESOURCES END

Detecting Radioactivity

18.3

Source of Background Radiation

- Some background radiation comes from high-speed nuclei, called cosmic rays, that strike Earth's atmosphere.



- They produce showers of particles, including alpha, beta, and gamma radiation.
- Most of this radiation is absorbed by the atmosphere.

CHAPTER RESOURCES END

Detecting Radioactivity

18.3

Radiation in Your Body

- Some of the elements that are essential for life have naturally occurring radioactive isotopes.
- For example, about one out of every trillion carbon atoms is carbon-14, which emits a beta particle when it decays.
- With each breath, you inhale about 3 million carbon-14 atoms.

CHAPTER RESOURCES END

Detecting Radioactivity

18.3

Radiation in Your Body

- The amount of background radiation a person receives depends on the type of rocks underground, the type of materials used to construct the person's home, and the elevation at which the person lives, among other things.

CHAPTER RESOURCES END

Section Check

18.3

Question 1

A device that measures the amount of radiation by producing electric current when it detects a charge particle is a __________.

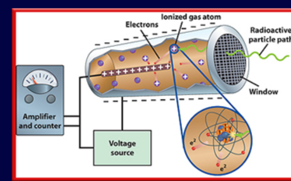
A. bubble chamber
B. cloud chamber
C. film badge
D. Geiger counter

Section Check

18.3

Answer

The answer is D. Cloud chambers and bubble chambers detect and monitor the paths of nuclear particles but do not generate electric current.



Section Check

18.3

Question 2

What is meant by the term "background radiation"?

Answer

Background radiation is low-level radiation emitted by naturally occurring radioactive isotopes in the environment.

Section Check

18.3

Question 3

The largest source of background radiation is from what type of radioactive decay?

A. alpha
B. beta
C. delta
D. gamma

Section Check

18.3

Answer

The answer is A. The largest source of background radiation is from the decay of radon gas, produced by the alpha decay of uranium-238.

Nuclear Reactions

18.4

Nuclear Fission

- In 1938, Otto Hahn and Fritz Strassmann found that when a neutron strikes a uranium-235 nucleus, the nucleus splits apart into smaller nuclei.

Nuclear Reactions

18.4

Nuclear Fission

- In 1939 Lise Meitner was the first to offer a theory to explain these results.
- She proposed that the uranium-235 nucleus is so distorted when the neutron strikes it that it divides into two smaller nuclei.

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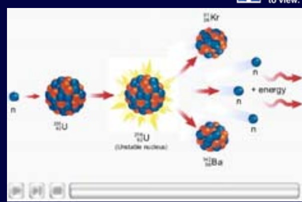
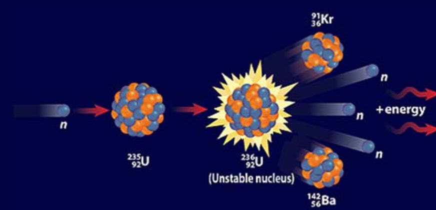


Nuclear Reactions

18.4

Nuclear Fission

- The process of splitting a nucleus into several smaller nuclei is **nuclear fission.**



Nuclear Reactions

18.4

Nuclear Fission

- The products of a fission reaction usually include several individual neutrons in addition to the smaller nuclei.
- The total mass of the products is slightly less than the mass of the original nucleus and the neutron.
- This small amount of missing mass is converted to a tremendous amount of energy during the fission reaction.

Nuclear Reactions

18.4

Mass and Energy

- Albert Einstein proposed that mass and energy were related in his special theory of relativity.
- According to this theory, mass can be converted to energy and energy can be converted to mass.

Nuclear Reactions

18.4

Mass and Energy

- The relation between mass and energy is given by this equation:
- A small amount of mass can be converted into an enormous amount of energy.

Mass-Energy Equation

Energy (joules) = mass (kg) × [speed of light (m/s)]^2

$$E = mc^2$$

Nuclear Reactions

18.4

Mass and Energy

- For example, if one gram of mass is converted to energy, about 100 trillion joules of energy are released.

Mass-Energy Equation

Energy (joules) = mass (kg) × [speed of light (m/s)]^2

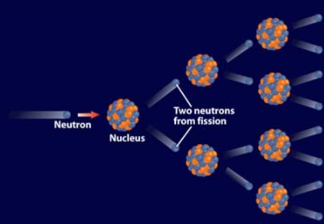
$$E = mc^2$$

Nuclear Reactions

18.4

Chain Reactions

- When a nuclear fission reaction occurs, the neutrons emitted can strike other nuclei in the sample, and cause them to split.



CHAPTER RESOURCES END

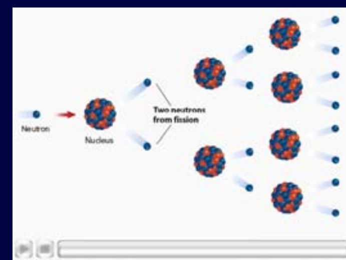
Nuclear Reactions

18.4

Chain Reactions

MAC OSX users click here to view.

- The series of repeated fission reactions caused by the release of neutrons in each reaction is a **chain reaction.**



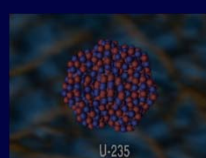
CHAPTER RESOURCES END

Nuclear Reactions

18.4

Chain Reactions

- A chain reaction can be controlled by adding materials that absorb neutrons.
- If enough neutrons are absorbed, the reaction will continue at a constant rate.



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CHAPTER RESOURCES END

Nuclear Reactions

18.4

Chain Reactions

- For a chain reaction to occur, a critical mass of material that can undergo fission must be present.
- The **critical mass** is the amount of material required so that each fission reaction produces approximately one more fission reaction.
- If less than the critical mass of material is present, a chain reaction will not occur.

CHAPTER RESOURCES END

Nuclear Reactions

18.4

Nuclear Fusion

- Tremendous amounts of energy can be released in nuclear fission.
- Even more energy can be released in another type of nuclear reaction, called nuclear fusion.

CHAPTER RESOURCES END

Nuclear Reactions

18.4

Nuclear Fusion

- In **nuclear fusion**, two nuclei with low masses are combined to form one nucleus of larger mass.
- Fusion fuses atomic nuclei together, and fission splits nuclei apart.

CHAPTER RESOURCES END

Nuclear Reactions

18.4

Temperature and Fusion

- For nuclear fusion to occur, positively charged nuclei must get close to each other.
- However, all nuclei repel each other because they have the same positive electric charge.

Nuclear Reactions

18.4

Temperature and Fusion

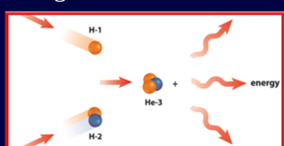
- If nuclei are moving fast, they can have enough kinetic energy to overcome the repulsive electrical force between them and get close to each other.
- Only at temperatures of millions of degrees Celsius are nuclei moving so fast that they can get close enough for fusion to occur.

Nuclear Reactions

18.4

Nuclear Fusion and the Sun

- Most of the energy given off by the Sun is produced by a process involving the fusion of hydrogen nuclei.
- This process occurs in several stages, and one of the stages is shown.

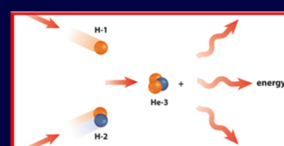


Nuclear Reactions

18.4

Nuclear Fusion and the Sun

- As this occurs, a small amount of mass is changed into an enormous amount of energy.
- An isotope of helium is produced when a proton and the hydrogen isotope H-2 undergo fusion.



Nuclear Reactions

18.4

Nuclear Fusion and the Sun

- As the Sun ages, the hydrogen nuclei are used up as they are converted into helium.
- So far, only about one percent of the Sun's mass has been converted into energy.
- It is estimated that the Sun has enough hydrogen to keep this reaction going for another 5 billion years.

Nuclear Reactions

18.4

Using Nuclear Reactions in Medicine

- Scientists can find one molecule in a large group of molecules if they know that it is "wearing" something unique.
- If it has a radioactive atom in it, it can be found easily in a large group of molecules, or even in a living organism.

Nuclear Reactions

18.4

Using Nuclear Reactions in Medicine

- When a radioisotope is used to find or keep track of molecules in an organism, it is called a **tracer**.
- Scientists can use tracers to follow where a particular molecule goes in your body or to study how a particular organ functions.

Nuclear Reactions

18.4

Using Nuclear Reactions in Medicine

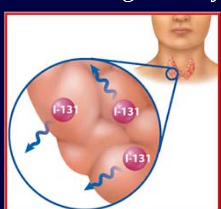
- Examples of tracers include carbon-11, iodine-131, and sodium-24.
- These three radioisotopes are useful tracers because they are important in certain body processes.
- As a result, they accumulate inside the organism being studied.

Nuclear Reactions

18.4

Iodine Tracers in the Tyhroid

- Because the element iodine accumulates in the thyroid, the radioisotope iodine-131 can be used to diagnose thyroid problems.



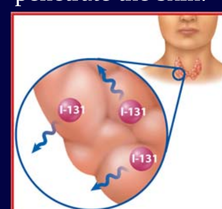
- As iodine-131 atoms are absorbed by the thyroid, their nuclei decay, emitting beta particles and gamma rays.

Nuclear Reactions

18.4

Iodine Tracers in the Tyhroid

- The beta particles are absorbed by the surrounding tissues, but the gamma rays penetrate the skin.



- The emitted gamma rays can be detected and used to determine whether the thyroid is healthy.

Nuclear Reactions

18.4

Iodine Tracers in the Tyhroid

- If the detected radiation is not intense, then the thyroid has not properly absorbed the iodine-131 and is not functioning properly.

Nuclear Reactions

18.4

Treating Cancer with Radioactivity

- Radiation can be used to stop some types of cancerous cells from growing.
- Remember that the radiation that is given off during nuclear decay is strong enough to ionize nearby atoms.
- If a source of radiation is placed near cancer cells, atoms in the cells can be ionized.

Nuclear Reactions

18.4

Treating Cancer with Radioactivity

- If the ionized atoms are in a critical molecule, such as the DNA or RNA of a cancer cell, then the molecule might no longer function properly.
- The cell then could die or stop growing.

CHAPTER RESOURCES END

Nuclear Reactions

18.4

Treating Cancer with Radioactivity

- When possible, a radioactive isotope such as gold-198 or iridium-192 is implanted within or near the tumor.
- Typically, an intense beam of gamma rays from the decay of cobalt-60 is focused on the tumor for a short period of time.
- The gamma rays pass through the body and into the tumor.

CHAPTER RESOURCES END

Nuclear Reactions

18.4

Treating Cancer with Radioactivity

- Cancer cells grow quickly, they are more susceptible to absorbing radiation and being damaged than healthy cells are.
- However, other cells in the body that grow quickly also are damaged, which is why cancer patients who have radiation therapy sometimes experience severe side effects.

CHAPTER RESOURCES END

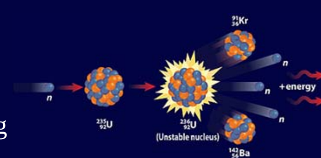
Section Check

18.4

Question 1

What process is being illustrated here?

A. chain reaction
B. nuclear fusion
C. nuclear fission
D. semiconducting



CHAPTER RESOURCES END

Section Check

18.4

Answer

The answer is C. Nuclear fusion occurs when two nuclei combine to form one nucleus.

CHAPTER RESOURCES END

Section Check

18.4

Question 2

A series of repeated fission reactions is called a(n) ___________.

A. chain reaction
B. critical mass
C. meltdown
D. uncontrolled reaction

CHAPTER RESOURCES END

Section Check

18.4

Answer

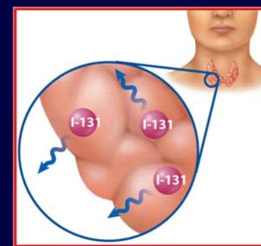
The answer is A. If the chain reaction is uncontrolled, an large amount of energy is released in an instant. Chain reactions are controlled by adding materials that absorb neutrons.

Section Check

18.4

Question 3

What is required in order for a radioisotope to be useful as tracers in nuclear medicine?



Section Check

18.4

Answer

A radioisotope must be important in body processes and accumulate in the organism being studied.

Help

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CHAPTER RESOURCES Click on this icon to open the resources file.

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End of Chapter Summary File