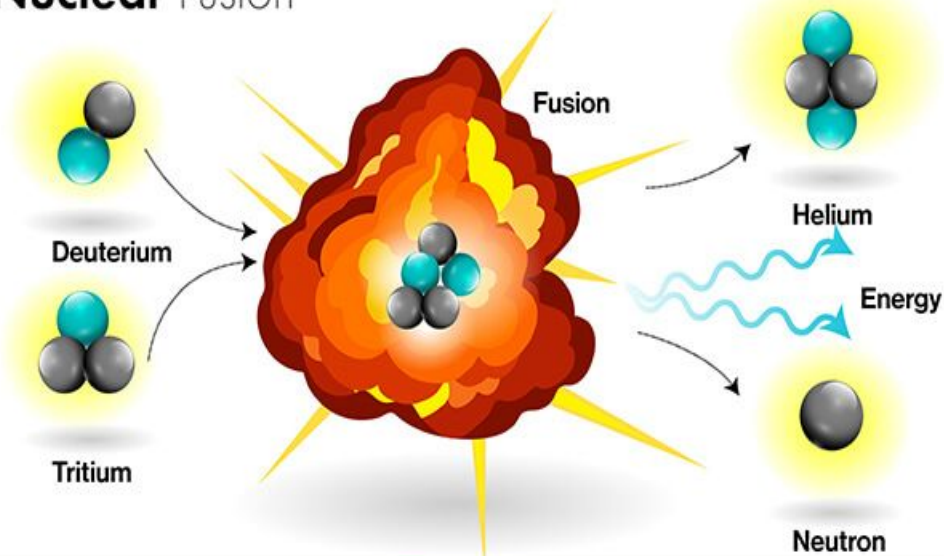


NUCLEAR PROCESSES

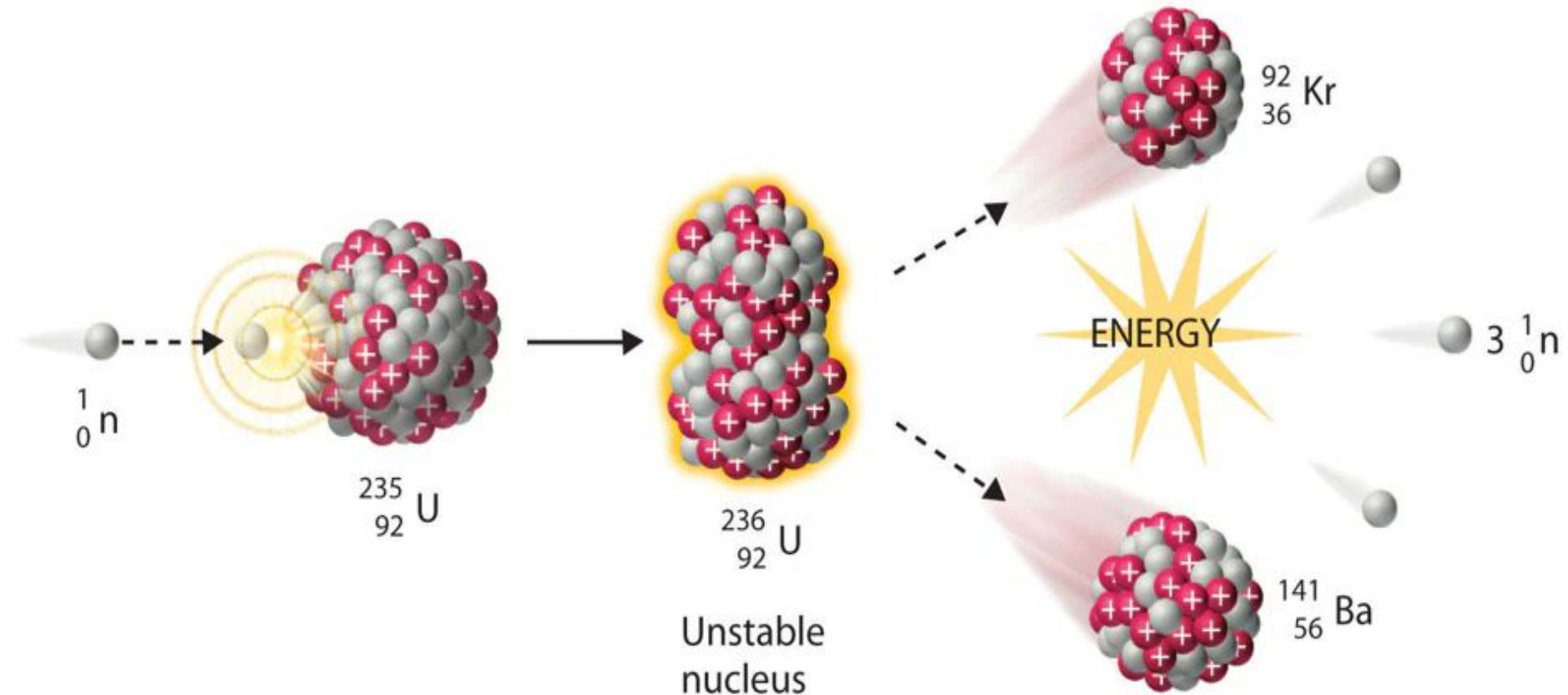
Nuclear Fusion



Nuclear Fusion

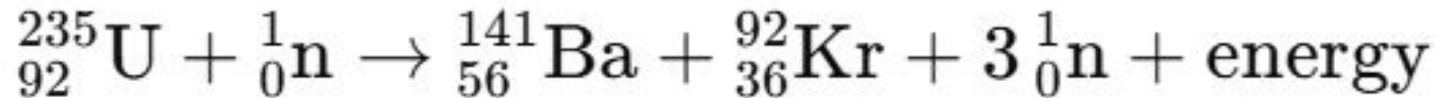


Nuclear fission



Nuclear fision

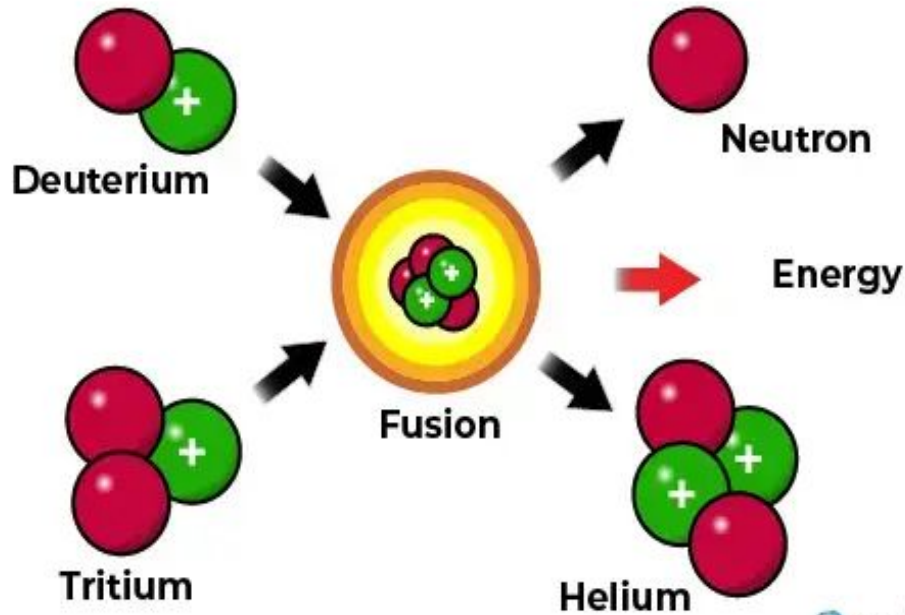
When a heavy unstable nucleus(Uranium-235) is bombarded with fast moving neutron splits to form lighter stable nuclei (barium-141 and krypton-92) with release of energy and more neutrons are formed. This energy can be used to produce nuclear power, light energy in controlled conditions



The neutrons bombard more nuclides, resulting in a chain reaction

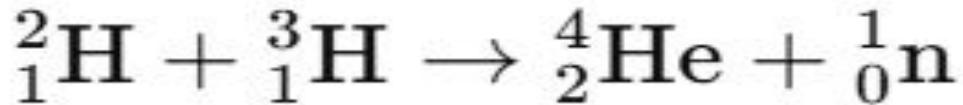
Nuclear fusion

Deuterium-Tritium Nuclear Fusion



Nuclear fusion

Occurs when two or more lighter stable nuclei such as deuterium and tritium combine under high temperature and pressure to form stable nucleus with release of energy used to produce electricity



+ Energy

Fusion reaction of hydrogen nuclides to form helium produces energy that powers the sun and other stars

Differences

Nuclear fission

Occurs in the nuclei of heavy elements

Splits heavy nuclei to lighter nuclei.

Can take place at ordinary temperatures.

Energy emitted during the process is very high.

Percentage efficiency of the energy conversion is comparatively less.

Nuclear fusion

Occurs in the nuclei of light elements.

Joins lighter nuclei to form heavy nuclei.

Takes place at high temperatures

Energy emitted during the process is comparatively low.

Percentage efficiency of the energy conversion is high (four times that of

SIDE EFFECTS AND THEIR MITIGATIONS

- ❖ The energy released can lead to mutations due to sudden change in structure of DNA of cells leading to alteration of characteristics of an individual.

Mitigation *use of lead shields to absorb any form of radiations*

- ❖ The energy emitted can cause cancer resulting into death as excess radiations can bring about uncontrolled cell division.

Mitigation *by wearing protective gears such as lead coats or by posting warning information in the working area*

❖ Energy from the process causes destruction of life and property, destructive nuclear programs deal with production of nuclear weapons which threaten the existence of humanity and property.

Mitigation *use of strict international policies on use of nuclear weapons/ alternative sources of energy like solar*

APPLICATIONS OF NUCLEAR REACTIONS

Nuclear reactors;

A nuclear reactor controls fission where by heavy nuclide is bombarded with fast moving neutrons and releases heat that is used to heat water and produce steam at high pressure which drives turbines that produce electricity in nuclear power plants.

Atomic bombs;

An atomic bomb derives its violent explosive power from the rapid release of energy by nuclear fission. An atomic bomb is set off by the rapid bringing together of uranium-235 and plutonium-239.

NUCLEAR REACTIONS

Are reactions that involve a change in an atom's number of protons or neutrons usually producing a different element.

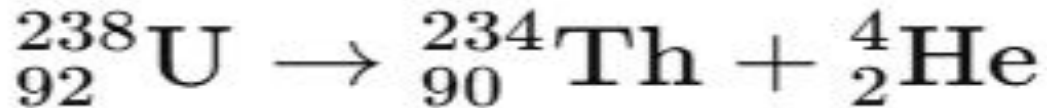
The spontaneous disintegration (decay) of unstable nuclides (nuclei) to form stable nuclides with emission of particles and radiations (energy) is called

Radioactivity.

Substances which undergo radioactivity are called Radioactive substance and the Isotopes which are Radioactive are also called Radioisotopes.

Radioactive decay

Nuclear decay occurs when unstable nucleus spontaneously change into a more stable nucleus with release of energy and particles such as beta, alpha and gamma rays used to sterilize medical equipments by killing bacterias



Note

Radioactivity is the spontaneous disintegration of unstable nuclide by emission of radiations and energy.

Types of radiations

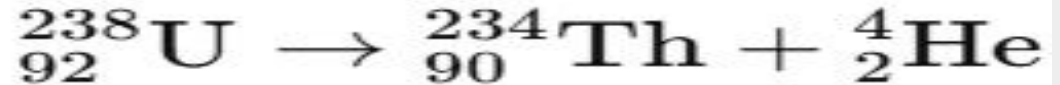
There are three types of radiations produced by a radioactive substance namely:-

1. Alpha particle (α -)
2. Beta particle (β -)
3. Gamma rays (γ -)

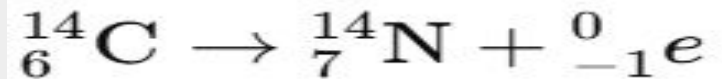
The alpha and beta radiations are called particles as a result of their appreciable mass

THE RADIATIONS PARTICLES

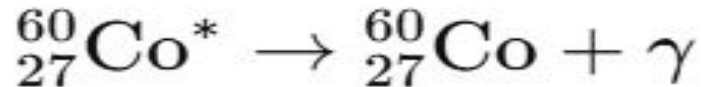
Alpha particles; The helium nuclide (nucleus) with symbol ${}^4_2\text{He}$ or α



Beta particles; is an electron with symbol ${}^0_{-1}e$ or β

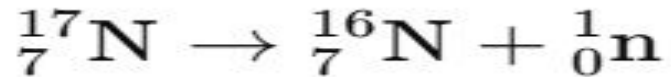


Gamma rays; which are electromagnetic radiations (waves) with symbol of γ



Protons; the hydrogen nuclide (nucleus) with symbol ${}_1^1\text{H}$

Neutrons; with the symbol ${}_0^1\text{n}$



A balanced radioactive equation

Is one where the sum of the mass numbers and the sum of the atomic numbers balance on either side of an equation.

1. Atomic number:

This is the number of protons or electrons in an electrically neutral atom.

2. Mass number:

This is the number of protons and neutrons in the nucleus of an atom.

If an atom of an element of mass number A and atomic number Z , has N number of neutrons then $A = N + Z$

3. Isotopes:

These are atoms of the same element with the same atomic number but different mass numbers. Isotopes of an element have the same chemical properties and occupy the same place in the periodic table.

Balancing radioactive equations

Ensure that the;

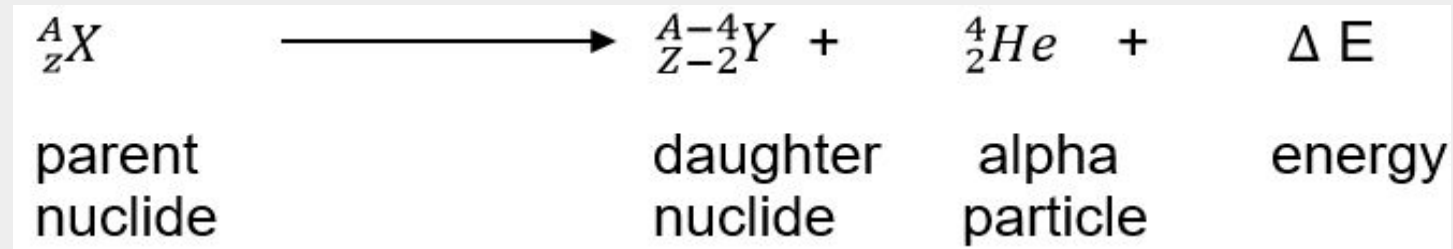
- Sum of the atomic numbers on the left should equal to the sum of atomic numbers on the right-hand side.
- Sum of the mass numbers on the left-hand side should be equal to that on the right-hand side

NB: When the emitted particle is known, the new nucleus formed is identified by its atomic number and NOT mass

Alpha decay

When a nuclide decays by emission of an alpha particle, it loses two protons and two neutrons. Hence its mass number reduces by 4 and its atomic number reduces by 2. The daughter nuclide (new nuclide) is two places earlier in the periodic table.

The general equation below shows a parent nuclide X which decays to a daughter nuclide Y by emission of an alpha particle and liberates nuclear energy.



Dangers and mitigation

- ❖ Alpha particles are extremely damaging to cells if emitted inside the body. This high local dose if misdirected or free α -emitter can heavily irradiate normal tissue (cancer increases).
mitigation . ***To minimize risk, modern nuclear medicine uses only short-lived α -isotopes at carefully calculated doses.***
- ❖ Workers handling α -emitting materials face grave hazards if particles are inhaled or ingested. If α -contaminated dust is breathed in it delivers a **very high dose to lung tissue** and, if translocated, to bone or liver, causing lung cancer even at relatively low exposures

Mitigation : ***Workers wear disposable coveralls, shoe covers, and double gloves.***

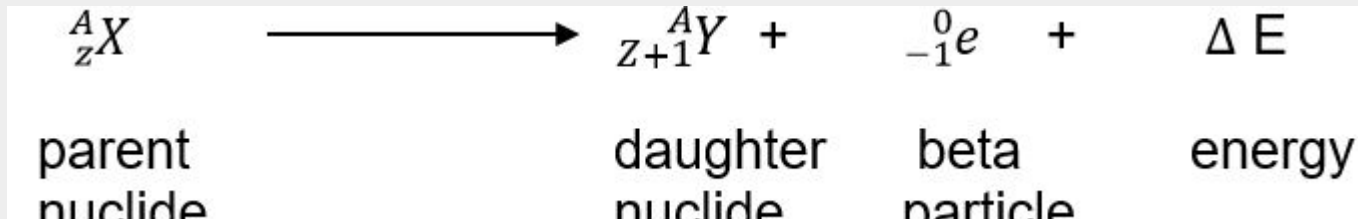
Uses of alpha particles

- ★ **Alpha-emitting isotopes are used to destroy cancer cells very precisely**
- ★ **Alpha sources are used in industries like paper, textile, and plastic manufacturing to remove static charges**

Beta decay

When a nuclide decays by emission of a beta particle, its neutron turns into a proton. The atom gains one protons, hence its mass number remains the same and its atomic number increases by 1.

The general equation below shows a parent nuclide X which decays to a daughter nuclide Y by emission of a beta particle and liberates nuclear energy.



Dangers and mitigation

- ❖ Therapeutic use of beta-emitting isotopes delivers high radiation dose to targeted tissues causing a risk of **local tissue damage** if not perfectly confined leading to severe **radiation burns, ulcers**

Mitigation. *Following Clinical protocols minimize these risks by using image-guided injection, calibrated dosing*

- ❖ Workers handling unsealed β -emitters face hazards of **skin and eye exposure**. energetic direct skin contact or contamination can cause “**beta burns**” – reddening, blistering or ulceration of the skin. Beta radiation to the eye can damage the lens hence loss of vision.

Mitigation ; *using safety glasses (plastic goggles) are recommended to stop β and prevent splashes*

Uses of beta particles

- ❖ Beta-emitting isotopes are used to destroy cancer cells while limiting damage to surrounding tissue
- ❖ Industries use beta sources to neutralize static charges on materials to prevent sparks
- ❖ Beta-emitting gases such as Krypton-85 are used to detect leaks in pipelines and sealed containers.

Gamma decay.

Gamma rays are **high-energy electromagnetic waves** released from the nucleus of unstable atoms during radioactive decay. Unlike alpha and beta particles, gamma rays:

Dangers and mitigation

- ❖ *Gamma radiations can cause mutations by causing sudden change in the structure of DNA of cells leading to alteration of characteristics of an individual.*

Mitigation; by wearing lead coats to protect workers from direct contact by the gamma rays

Uses of gamma particles

- ★ *Gamma radiations are used to sterilize medical tools by killing bacteria and other pathogens*
- ★ Gamma rays help doctors see inside the body where small radioactive tracer is injected into the body. The tracer emits gamma rays that are detected by special cameras to create images of organs.
- ★ Gamma rays are used to check for cracks /defects in metal structure

PROPERTIES OF THE RADIATIONS

Alpha	Beta	Gamma
the heaviest and travel at slowest speed	the heavier and travel at slower speed	They are light and travel at faster speed
have very low penetrating power. They do not pass through a sheet of paper	have a higher penetrating power. They can pass through a sheet of paper but are blocked by a sheet of aluminium	They have the highest penetrating power. They pass through a sheet of paper and a sheet of aluminium but are blocked by a thick lead or steel block

Alpha	Beta	Gamma
<i>Alpha particles have high ionizing power. This is enhanced by their strong positive charge and slow speed due to high mass.</i>	<i>Beta particles have moderate ionizing power due to no mass and high speeds •</i>	<i>Gamma rays have no mass and no charge and move at high velocity therefore, they do not cause ionization as they pass through substances.</i>
<i>Alpha particles are deflected towards the south pole.</i>	<i>Beta particles are deflected towards the north pole. Beta particles can be deflected by a much weaker magnetic field than alpha particles</i>	Gamma rays are unaffected thus no deflection

Alpha	Beta	Gamma
<p><i>•Alpha particles being positively charged and are deflected (attracted) towards the negative plate.</i></p>	<p><i>•Beta particles are negatively charged and are deflected(attracted) towards the positive plate.</i></p>	

Ionizing power refers to the ability of radiation (alpha, beta, or gamma rays) to remove tightly bound electrons from atoms resulting in the formation of ions. The ability of radioactive emissions to form ions depends on mass and the charge of the radiation.

Half life

Half-Life is defined as the time taken for the number of atoms of a radioactive substance to decay to one half of its original value.

Units of Half-Life

The half-life can be in seconds, minutes, hours, days, months, weeks and years.

Radioactive decay curve

