LIBERTY & SUCCESS LEARNING HUB
NUCLEAR PHYSICS / CHEMISTRY

NUCLEAR REACTION, NUCLEAR REACTOR, FISSION AND FUSION

NUCLEAR REACTION

A nuclear reaction is a reaction that involves a change in the nucleus of an atom, resulting in the formation of a new nucleus and the release or absorption of a very large amount of energy.

Unlike chemical reactions (which involve electrons), nuclear reactions involve protons and neutrons inside the nucleus.

Features of nuclear reactions

- Occur in the nucleus of atoms
- Produce very large energy
- Can change one element into another
- Not affected by temperature or pressure

Example: When uranium breaks into smaller nuclei and releases energy, a nuclear reaction has occurred.

TYPES OF NUCLEAR REACTIONS

There are two main types of nuclear reactions:

1. Nuclear fission
2. Nuclear fusion

NUCLEAR FISSION

Nuclear fission is the process in which a heavy nucleus splits into two or more smaller nuclei, releasing a large amount of energy.

How nuclear fission happens

- A heavy nucleus (e.g. uranium-235) absorbs a neutron
- The nucleus becomes unstable
- It splits into smaller nuclei
- Energy and more neutrons are released

Example

Uranium-235 splits into barium and krypton plus energy.

Important points

- Occurs in nuclear reactors
- Produces radioactive waste
- Can cause a chain reaction

Uses of nuclear fission

- Generation of electricity in nuclear power stations
- Atomic bombs (e.g. Hiroshima bomb)

CHAIN REACTION

A chain reaction is a process where neutrons released from one fission reaction cause further fission reactions.

If not controlled, it can lead to a violent explosion.

NUCLEAR REACTOR

A nuclear reactor is a device used to control nuclear fission and use the energy released to generate electricity.

Main parts of a nuclear reactor and their functions

1. Fuel rods
    - Contain uranium-235
    - Where fission takes place
2. Control rods
    - Made of boron or cadmium
    - Absorb excess neutrons
    - Control the rate of reaction
3. Moderator
    - Usually water or graphite
    - Slows down fast neutrons
4. Coolant
    - Removes heat from the reactor
    - Prevents overheating
5. Shielding
    - Thick concrete walls
    - Protects people from radiation

USES OF NUCLEAR REACTORS

a. Generation of Electricity

Nuclear energy is used to **generate electricity** by converting heat energy from nuclear reactions into electrical energy.

Explanation:
In a nuclear power station, **nuclear fission** of uranium produces a large amount of heat. This heat turns water into steam. The steam rotates turbines connected to generators, which then produce electricity.

Example:
Electricity generated from **uranium-235 fission** in nuclear power stations in countries like France and the USA.

b. Research

Nuclear reactors are used for **scientific research** to study nuclear reactions and the behavior of radioactive materials.

Explanation:
Controlled nuclear reactions allow scientists to carry out experiments safely. These experiments help improve knowledge in physics, chemistry, agriculture, and engineering.

Example:
Use of **research reactors** in universities and laboratories to study atomic structure and radiation effects.

c. Production of Radioactive Materials for Medicine

Nuclear reactors are used to produce **radioactive isotopes** that are useful in medicine.

Explanation:
Some radioactive substances produced in reactors are used to **diagnose and treat diseases**, especially cancer.

Example:

- **Cobalt-60** used in cancer treatment (radiotherapy)
- **Iodine-131** used to treat thyroid diseases

NUCLEAR FUSION

Nuclear fusion is the process in which two light nuclei combine to form a heavier nucleus, releasing a very large amount of energy.

Process of Nuclear fusion

- Light nuclei (e.g. hydrogen isotopes) collide
- They join together at very high temperature
- A heavier nucleus is formed
- Energy is released

Example: Two hydrogen nuclei combine to form helium.

- Occurs naturally in the Sun and stars
- Requires extremely high temperature
- Produces more energy than fission
- Does not produce dangerous radioactive waste

Uses of nuclear fusion

- Source of energy in the Sun
- Hydrogen bomb (thermonuclear bomb)
- Future source of clean energy (still under research)

DIFFERENCES BETWEEN FISSION AND FUSION

Nuclear Fission	Nuclear Fusion
Heavy nucleus splits	Light nuclei combine
Uses uranium or plutonium	Uses hydrogen isotopes
Occurs in reactors	Occurs in the Sun
Produces radioactive waste	Little or no waste
Lower temperature required	Very high temperature required

ADVANTAGES AND DISADVANTAGES

Advantages of nuclear energy	**Disadvantages of nuclear energy**
Produces large amount of energy	Produces radioactive waste
Requires small amount of fuel	Risk of radiation leaks
Useful for electricity generation	Expensive to set up