JSR IAS ACADEMY

GENERAL SCIENCE

PHYSICS

NUCLEAR REACTOR

NUCLEAR REACTOR

- A Nuclear reactor is a device in which the nuclear fission reaction takes place in a **self-sustained** and controlled manner to **produce electricity.**
- The **first nuclear reactor** was built **in 1942 at Chicago, USA.**

Types of nuclear reactors

- Breeder reactor,
- fast breeder reactor,
- pressurized water reactor,
- pressurized heavy water reactor,
- boiling water reactor,
- watercooled reactor,
- gas-cooled reactor,
- fusion reactor and
- thermal reactor

Components of a nuclear reactors

The essential components of a nuclear reactor are

(i) fuel,

(ii) moderator,

(iii) control rod,

(iv) coolant and

(v) protection wall.

Fuel:

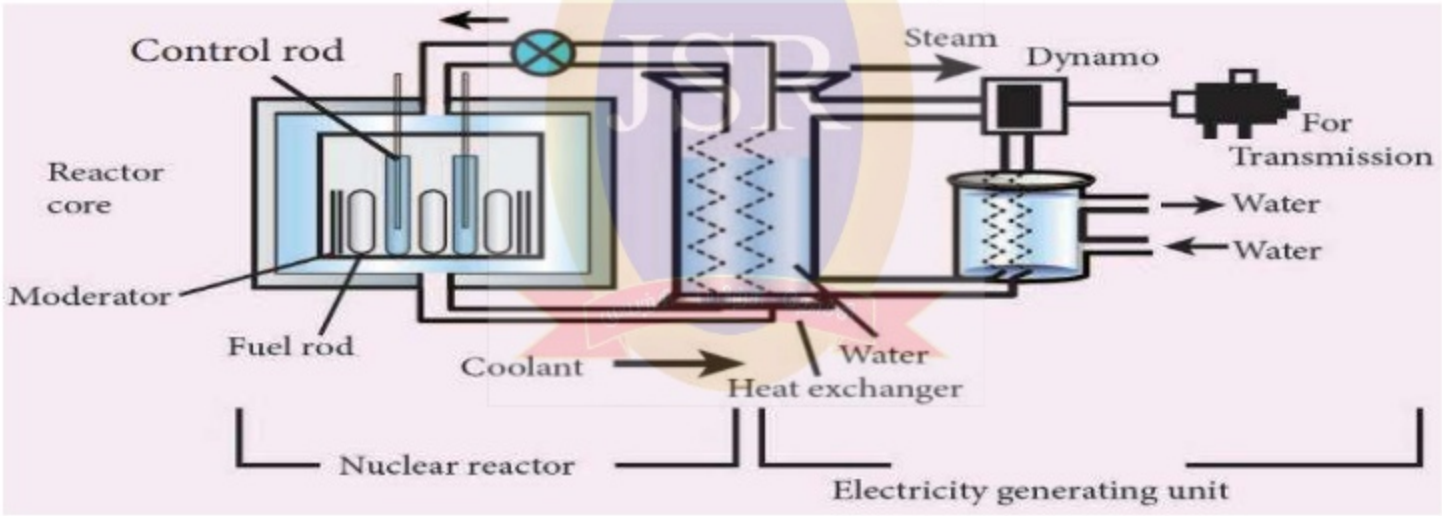
A fissile material is used as the fuel. The commonly used fuel material is **uranium.**

Moderator:

- A moderator is **used to slow down the high energy neutrons to provide slow neutrons**.
- **Graphite and heavy water** are the commonly used moderators.

Control rod:

- Control rods are **used to control the number of neutrons in order to have sustained chain reaction.**
- Mostly **boron or cadmium** rods are used as control rods. They **absorb the neutrons.**



Coolant:

- A coolant is **used to remove the heat** produced in the reactor core, to produce steam.
- This steam is used to run a turbine in order to produce electricity.
- **Water, air and helium** are some of the coolants.

Protection wall:

A thick concrete lead wall is built around the nuclear reactor in order to **prevent the harmful radiations from escaping into the environment.**

Uses of a nuclear reactor

- Nuclear reactors are widely used in **power generation.**
- They are also used to **produce radio isotopes,** which are used in a variety of applications.
- Some reactors **help us to do research in the field of nuclear physics.**
- **Breeder reactors** are **used to convert nonfissionable materials into fissionable materials.**

Nuclear power plants in India

- Indian **Atomic Energy Commission (AEC)** was established in August **1948** by the Department of Indian Scientific Research committee at Bombay (now Mumbai) in Maharashtra.
- **Dr. Homi Jahangir Bhaba** was the first chairman of Indian Atomic Energy Commission.
- Now, it is known as **Bhaba Atomic Research Centre (BARC).**
- Nuclear power is the **fifth largest source of power in India.**
- **Tarapur Atomic Power Station** is India's first nuclear power station.

Now, there are a **total of seven power stations**,

- one each in **Maharashtra, Rajasthan, Gujarat, Uttar Pradesh** and
- two in **Tamilnadu.**

- In **Tamilnadu,** we have nuclear power stations in **Kalpakkam and Kudankulam.**
- **Apsara** was the **first nuclear reactor built in India and Asia.**
- Now, there are **22 nuclear reactors** which are operating in India.

Some other operating reactors are

- Cirus
- Dhuruva
- Purnima

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USES OF RADIOACTIVITY

Agriculture

- The radio isotope of **phosphorous (P-32)** helps to increase the productivity of crops.
- The radiations from the radio isotopes **can be used to kill the insects and parasites and prevent the wastage of agricultural products.**

Medicine

Medical applications of radio isotopes can be divided into two parts:

i) Diagnosis

ii) Therapy Radio isotopes

are used as tracers to **diagnose the nature of circulatory disorders of blood, defects of bone metabolism, to locate tumors,** etc.

Some of the radio isotopes which are used as tracers are: **hydrogen, carbon, nitrogen, sulphur**, etc.

- **Radio sodium (Na24)** is used for the effective functioning of heart.
- **Radio – Iodine (I131)** is used to cure goiter.
- **Radio-iron is (Fe59)** is used to diagnose anaemia and also to provide treatment for the same.
- **Radio phosphorous (P32)** is used in the treatment of skin diseases.
- **Radio cobalt (Co60)** and **radio-gold (Au198)** are used in the treatment of skin cancer.

Industries

- An isotope of **californium (Cf 252)** is used in the airlines to detect the explosives in the luggage.
- An isotope of **Americium (Am241)** is used in many industries as a smoke detector.

Archeological research

- **Using the technique of radio carbon dating,** the age of the Earth, fossils, old paintings and monuments can be determined.
- In radio carbon dating, the existing amount of radio carbon is determined and this gives an estimate about the age of these things.

Identify A, B, C, and D from the following nuclear reactions.

(i) $_{13}Al^{27} + A \longrightarrow {}_{15}P^{30} + B$

(ii) $_{12}Mg^{24} + B \longrightarrow {}_{11}Na^{24} + C$

(iii) $_{92}U^{238} + B \longrightarrow {}_{93}Np^{239} + D$

Answer

(i) $_{13}Al^{27} + {}_{2}He^{4} \longrightarrow {}_{15}P^{30} + {}_{0}n^{1}$

(ii) $_{12}Mg^{24} + {}_{0}n^{1} \longrightarrow {}_{11}Na^{24} + {}_{1}H^{1}$

(iii) $_{92}U^{238} + {}_{0}n^{1} \longrightarrow {}_{93}Np^{239} + {}_{-1}e^{0}$

A is alpha particle, B is neutron, C is proton, and D is electron.

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A radon specimen emits radiation of 3.7×10^{3} GBq per second. Convert this disintegration in terms of curie. (one curie = 3.7×10^{10} disintegration per second)

1 Bq = one disintegration per second

one curie = 3.7×10^{10} Bq

1 Bq = $\frac{1}{3.7 \times 10^{10}}$ curie

3.7×10^3 G Bq = $3.7 \times 10^3 \times 10^9 \times \frac{1}{3.7 \times 10^{10}}$

= 100 curie

$_{92}U^{235}$ experiences one **α** - decay and one **β** - decay. Find number of neutrons in the final daughter nucleus that is formed.

Solution:

Let X and Y be the resulting nucleus after the emission of the alpha and beta particles respectively.

$_{92}U^{235} \xrightarrow{\alpha \text{ decay}} {}_{90}X^{231} + {}_{2}He^{4}$

${}_{90}X^{231} \xrightarrow{\beta \text{ decay}} {}_{91}Y^{231} + {}_{-1}e^{0}$

Number of neutrons = Mass number – Atomic number

= 231 – 91 = 140

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Calculate the amount of energy released when a radioactive substance undergoes fusion and results in a mass defect of 2 kg.

Solution:

Mass defect in the reaction (m) = 2 kg

Velocity of light (c) = 3×10^8 m s^{-1}

By Einstein's equation,

Energy released $E = mc^2$

So $E = 2 \times (3 \times 10^8)^2$

$= 1.8 \times 10^{17}$ J

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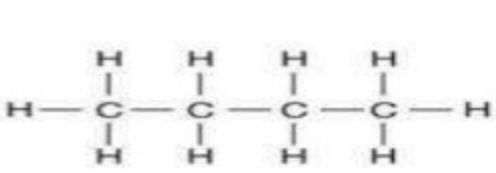
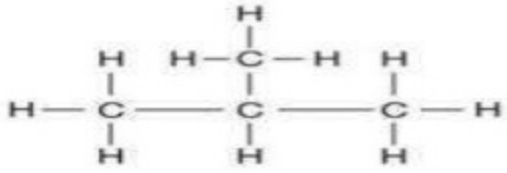
What Is A Structural Isomer?

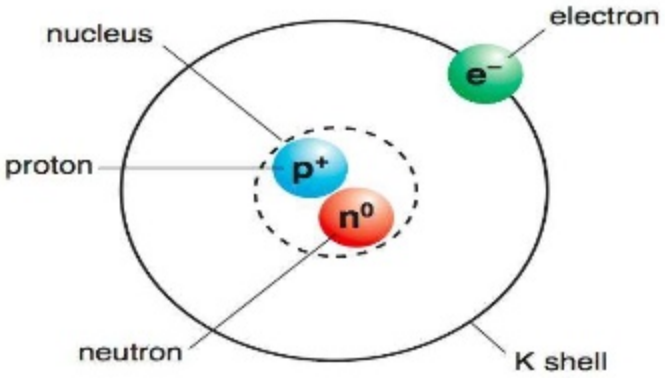
A structural isomer is any of two or more chemical compounds having the same molecular formula but different structural formulas



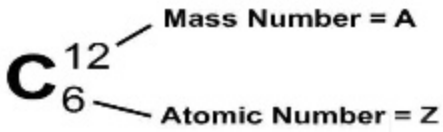
Butane



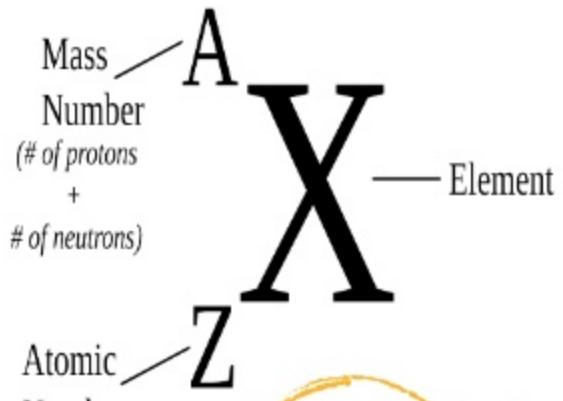
Isobutane



C_{6}^{12} C_{6}^{14}



Atomic Symbol



revision science

Isotopes	Isobars	Isotones
Same Atomic Number	Same Atomic mass number	Same number of Neutrons
Number of protons & electrons are same. Neutrons only differ	All neutrons, protons, and electrons differ	Number of neutrons are same Number of electrons & Proton differ
Iso means Same, P stands for Protons	Iso means same, Baros means weight	Iso means same, N means Neutrons