6 NUCLEAR PHYSICS

What we have already learnt

- **Atom:** The smallest unit of an element with all its properties.
- **Structure of an atom:** A very small nucleus at the centre and electrons revolving around the nucleus in different orbits.
- **Nucleus:** Centre of an atom comprising of neutrons and protons.
- **Proton - electron - neutron-** Particles with positive charge, negative charge and without any charge respectively.
- **Atomic number:** Number of protons in a nucleus.
- **Mass number :**Total number of protons and neutrons in an atom.
- **Isotopes:** Atoms of the same element having different mass numbers
- **Energy:** capacity to do work.

You have learnt about chemical reactions in your chemistry classes. Haven't you noticed that nucleus is not involved in chemical reactions? But there are certain reactions in which the structure of nucleus also changes. It was in the thirtees of the twentieth century that scientists came to know about such reactions. This led to the possibility of producing energy on a large scale which resulted in tremendous changes in the areas of health, industry, research etc. In this chapter let us try to understand more about the nucleus of an atom and the reactions that cause changes in the nucleus.

6.01 Isotopes and isobars

See table 6.1 given below. Complete the table using the missing numbers

Elements	Mass number	Proton/ Atomic number	Neutron
Helium	4	2	4-2 = 2
Carbon	12	6	6
Aluminum	27	13	--
Calcium	40	--	20
Radon	--	86	136
Radium	227	--	139
Thorium	232	--	142
Uranium	--	92	146

Table 6.1

What are the peculiarities that can be found about elements in the table.

- In elements with lower atomic number, the number of protons, and the number of neutrons will be more or less the same.
-

In table 6.2 symbols of certain elements are given. Complete the table by using their atomic number and mass number.

Element	Symbol	Atomic number	Mass number
Carbon	${}_{6}C^{12}$	6	12
	${}_{6}C^{14}$	6	14
Nitrogen	${}_{7}N^{14}$		
	${}_{7}N^{16}$		
Lead	${}_{82}Pb^{198}$		
	${}_{82}Pb^{204}$		
Bismuth	${}_{83}Bi^{198}$		
	${}_{83}Bi^{204}$		

Table 6.2

What additional information do we gather when we analyse table 6.2?

- Even if the atomic number of all the atoms in an element is the same, their mass numbers need not be so.
- Similarly atoms of different elements may have the same mass number.

Atoms of the same element (having the same atomic number) with different mass numbers are called isotopes.

Atoms of different elements (i.e., atoms of different atomic number) with same mass number are called isobar.

Study table 6.3 and note down the isotopes and isobars

Find out more examples of isobars and isotopes and note them down in your science diary.

Elements	Symbol	Atomic number	Mass number
Radium	$_{88}Ra^{221}$		
	$_{88}Ra^{223}$		
Thorium	$_{90}Th^{232}$		
	$_{90}Th^{231}$		
Protactinium	$_{91}Pa^{234}$		
	$_{91}Pa^{231}$		
Uranium	$_{92}U^{234}$		
	$_{92}U^{235}$		

Table 6.3

6.02 Natural radioactivity

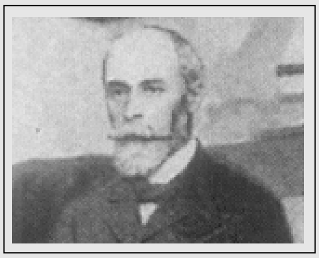
You have understood that in the nucleus of atoms having lower mass number, the number of protons and neutrons will be more or less the same. But as the atomic mass increases difference between the number of neutrons and the number of protons is found to be increasing. When the ratio between the number of neutrons and protons remains within certain numerical limit, such atoms are stable. The nucleus of isotopes whose neutron - proton ratio is not within this limit will undergo rearrangement releasing energy. This is called natural radioactivity.

Can you frame a practical definition for natural radioactivity?

When neutron - proton ratio of an element is not within a certain limit, the nucleus undergoes rearrangement emitting energy. This process of decay is called natural radio-activity.

Radioactivity was discovered by Henry Becquerel. While doing experiments relating to fluorescence he found radioactive radiation emerging from a Uranium salt used for the experiment. Later the scientists Pierie Curie and Madam Curie discovered two more elements showing powerful radio activity. They are Radium and Polonium.

Henry Becquerel

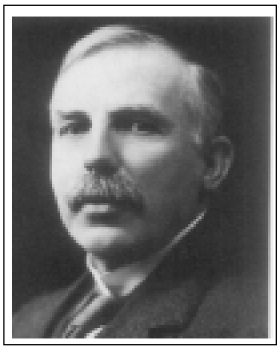


The French scientist Henry Becquerel discovered the phenomenon of radioactivity quite accidentally in 1886. He noticed a chemical change on the photographic plate covered with black paper and kept within the drawer of his table for conducting experiments on fluorescence. He found that the radiations emitted by the uranium salt kept over the photographic plate caused the chemical changes on the photographic plate. The radiations are not affected by physical or chemical conditions. So he concluded that this phenomenon was due to some unknown radiations.

6.03 Radioactive radiation

We have already learnt that the nucleus of certain isotopes radiate energy and rearrange themselves. What are the different types of radiations emitted from the nucleus?

The British scientist Earnest Rutherford in 1903 conducted experiments and found out different types of radioactive radiations.



Earnest Rutherford

He placed a small piece of radium in the small pit of a lead block. The radiations from the piece of uranium were seen affected by the electric field as they passed through it. Observe the path of different radiations and arrive at the various possible conclusions.

- In the electric field the radioactive radiations split into three distinct components
- One part consists of negatively charged particles. They are deflected towards the positive plate of the electric field.
-

Radiations with positively charged particles are called Alpha(α) rays and negatively charged particles are called Beta rays(β). Radiations without any charge are

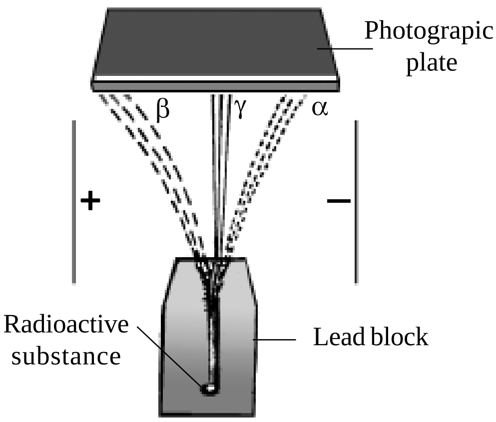


figure 6.1
Radiations from radioactive substance passing through an electric field.

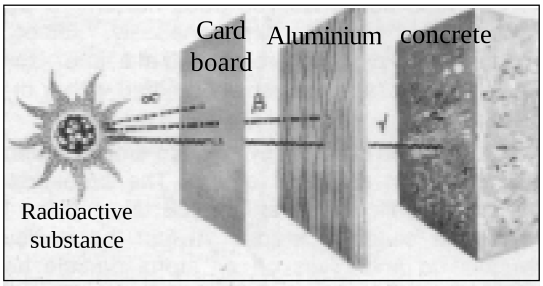


figure 6.2
Picture showing the relative strength of penetrating power of radiations α,β,γ

called Gamma rays (γ). α rays are positively charged and it consists of the nuclei of Helium atom. βrays consist of electrons. γ rays are without any charge and are high energy electromagnetic radiation of very short wave length.

See the properties of Alpha, Beta and Gamma rays from the table 6.4

The Gamma rays are emitted from the nucleus along with Alpha and Beta particles. But Alpha and Beta particles are not emitted simultaneously from the nucleus.

Madam Curie (1867-1934)

Mary Sklodowska Curie was born in 1867 as the daughter of a professor of physics in a Varsity in Poland. Her father lost his job owing to some domestic problems in Poland. Her mother died of illness. Subsequently she grew up in a poor family back-ground. She worked hard for money and went to Paris for higher studies. She passed her degree examination in First rank. She married Pierie in 1895 and

Alpha rays	Beta rays	Gamma rays
• Stream of radiation of positively charged particles.	• Stream of radiation of negatively charged particles	• Radiation without any charge
• Particles are equivalent to Helium nucleus (consist of 2 protons and 2 neutrons).	• Beta particles are electrons	• Electromagnetic radiation
• Velocity is 2×10^7m/s	• Velocity is 2 10^8m/s	• Velocity is 3 10^8m/s
• The ability to ionise gases is very high.	• The ability to ionise gases is less than that of α particles	• The ability to ionise gases is very low.
• Penetrating power is very low.	• Penetrating power is higher than that of α particles.	• Have the highest penetrating power.

Table 6.4

after that they worked together. She was greatly interested in the radioactivity found out by Henry Becquerel. It was Mary who named the Phenomenon as radioactivity.

She filtered nearly one tonne of uranium ore to extract 1/10 of a gram of uranium and this shows her hard working nature. In 1898 Polonium was separated from Uranium ore. After four years she separated Radium also.

In 1903 Madam Curie and Pierie curie were awarded Nobel Prize along with Henry Becquerel for the works related to radio activity. In 1911 Madam Curie was awarded Nobel prize in chemistry also for separating Polonium and Radium.

In 1906 Pierie Curie died in an accident. After that Madam Curie was appointed as Professor in Sorbon in the place of her late husband.

Owing to continuous exposure to radio-active radiations Madam Curie died of blood cancer in 1934.

The changes caused by radiation in the nucleus

Let us try to understand the changes taking place in the nucleus when radioactive radiations are produced. Alpha particle is identical to the nucleus of Helium atom. What happens to the nucleus of a radioactive element when an α particle ($_2He^4$) is emitted?

- Atomic number of the element decreases by 2.
-

What happens during the emission of Beta particle from the nucleus? β particles are electrons. Before a β particle is emitted the neutron in the nucleus splits up to form a proton and an electron. This electron is the β particle that is emitted. Proton remains in the nucleus. What is the change that occurs in the nucleus of the radioactive element?

- The atomic number of the element increases by one.
- Mass number of the element does not change.

6.04 Half life period

The stability and the disintegration rate of radioactive substances are measured using half life period.

The time period required for a radioactive isotope to disintegrate itself to half its initial mass is called half life period of that radio active isotope.

Element having longer half life period will have low disintegration rate and are more stable.

- The half life period of iodine -131 is 8 days. How much portion of the element remains after 32 days?

after 8days part

after 16 days $\frac{1}{4}$ part

$\frac{1}{8}$ after 24 days part

after 32 days $\frac{1}{16}$ part

- A period of 27,000 years is needed to change 100g. radio isotope Curium to become 12.5g. So what is the half life of Curium?

6.05 Artificial radioactivity

Elements which are not naturally radio-active can be made radioactive isotopes.

We know that natural radioactivity is due to the higher value of neutron- proton ratio in elements. The number of neutrons in the nuclei of atoms with lower mass numbers can be increased above their normal value by artificial means. Then the elements becomes radio active.

Atoms of low mass number are in general not radioactive. These atoms can be made radioactive by artificial means. The radioactivity so created is called artificial radioactivity and the atoms thus created are called radioisotopes.

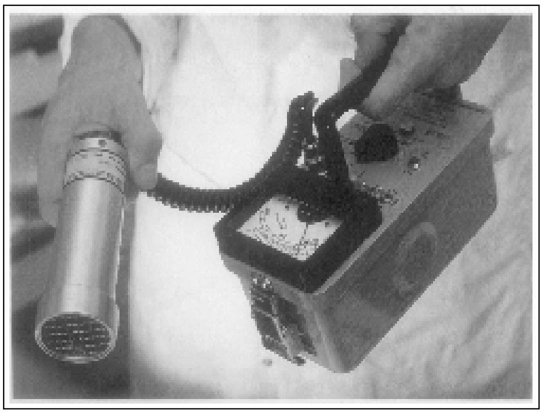


figure 6.3
A Geiger counter to measure radioactivity

Even though Earnest Rutherford started the work leading to these discoveries it was fully realised by Irene Juliot and Frederick Juliot.

6.06 Uses of radioisotopes

Radioisotopes have great importance in the world of science. In the areas like medicine, industry, research etc. radioisotopes are used. Some of them are given below. Find out more and write them down.

- Used in the treatment of cancer.
- It is used as a tracer for diagnosing diseases and also for determining the efficiency of thyroid gland, kidney etc.
- To sterilize surgical instruments.
- To produce high yielding seeds.
- Used as a tracer to determine the effects produced by chemical substances in plants and animals.

- To determine the age of fossils.
- Used to identify the defects in metal castings and pipes.
- To sterilize food stuffs.
-

To diagnose diseases, radioisotopes are mixed with elements which are not radioactive and is passed as a tracer to measure radioactivity. For this an instrument called Geiger counter is used. As Gamma radiations have the power to destroy cells, they are made to fall on the parts affected by cancer. For this radioisotopes like cobalt-60 are used. As the Gamma rays can penetrate through metallic substances they are passed through them and caught on a photographic film and thus cracks are detected.

Medicines which contain radioisotopes used for the diagnosis and treatment of diseases are called Radio Pharmaceutical Substances (RPS).

figure 6.4
A Cobalt radio therapy unit

Carbon Dating

The process by which the ages of fossils and autiques made of biomaterial are determined using the radioisotope carbon 14 is called carbon dating. When the cosmic rays from the outer space reach the earth's atmosphere, they collide with different kinds of atoms in our upper atmosphere producing neutron, proton and other particles. The neutron collides with the nucleus of nitrogen atom giving rise to radio carbon isotope of mass number 14.

$${}_0n^1 + {}_7N^{14} \rightarrow {}_1H^1 + {}_6C^{14}$$

Radio carbon decays itself into ${}_7N^{14}$. The half life of radio carbon is 5760 years. Though the atoms of radio carbon decay gradually the temperature of C^{14} atoms in the living plants remain constant because of the above nuclear reactions taking place in the atmosphere. Plants absorb radio carbon along with CO_2 during photosynthesis. When plants and animals die they stop taking in CO_2. But the C^{14} in them continues to decay. At the time when plants and animals die, the amount of C^{14} in them is in the same ratio as that in the atmosphere. Using Geiger counter, radiations from the dead substances are measured and the ratio of the remaining C^{14} can be found out. Comparing this with the ratio of C^{14} in the atmosphere the age of fossils can be calculated.

6.07 Mass defect and binding energy

More than one neutron and proton are seen in the nucleus of all the elements except hydrogen. Do you know the source of energy that binds the protons together and keeps them within the nucleus inspite of repulsion and from spliting the nucleus?

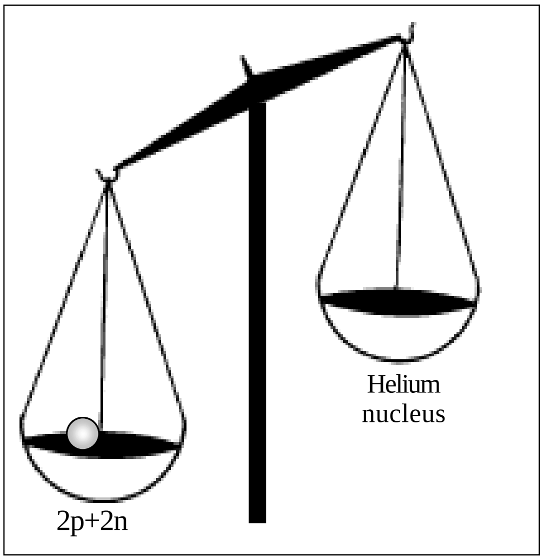


figure 6.5

Mass defect in an artist's view

In table 6.5 the details of a helium nucleus are given

Particle	Mass
Neutron (n)	1.008665 u
Proton (p)	1.007276 u
Total mass of the nucleons in a helium nucleus = 2p+2n	4.03188u

Table 6.5

The total mass of nucleons in the Helium nucleus is calculated in the table but the actual mass of Helium nucleus is 4.001505u, that is, 0.03037u less than that of the total mass of the nucleons taken separately.

Atomic mass unit (a.m.u)

The unit that is used to measure the mass of an atom and its particles inside is called atomic mass unit. The mass of C^{12} atom is 12u and its 1/12 part is called 1 a.m.u or u.

1 u =

$$= \frac{1.992678 \times 10^{-26}\,kg}{12}$$

$$= 1.6605678 \times 10^{-27} kg.$$

Atomic mass unit is expressed by the symbol u.

The difference between the rest mass of the nucleus and the sum of the masses of protons and neutrons in a nucleus is known as mass defect.

What happens to the lost mass? This mass converts itself into energy. This energy utilized to bind the nucleons in the nucleus is called binding energy.

When matter is converted into energy it is measured by the Einstein formula $E = mc^2$.

You know that E denotes energy, m-mass, c- velocity of light. Now let us calculate the binding energy of helium.

Actual mass of Helium nucleus = 4.001505u

Total mass of 2 protons and two neutrons = 4.03188u

Mass defect = 4.03188 - 4.0015054

= 0.030375u

Mass defect in kg

$= 0.030375 \quad 1.6605678 \quad 10^{-27}kg$

$= 0.05044 \quad 10^{-27}kg$

Velocity of light $c = 3 \quad 10^8 m/s$

Binding energy

$= mc^2 = 0.05044 \quad 10^{-27} \quad [3 \quad 10^8]^2$

$= 0.4539 \quad 10^{-11} J$

- Find out the binding energy of $_3Li^7$ nucleus, from the data given below. Mass of Proton = 1.007825u

  Mass of neutron = 1.008665u

  Velocity of light = 3 10^8 m/s,
  1u= 1.6605678 10^{-27} kg

  Atomic mass of $_3Li^7$= 6.940u.

6.08 Nuclear force

You have already seen that the energy required to bind the nucleons in a nucleus is called binding energy. Owing to this, the nucleons are strongly attracted one another by a force. This strong force is called nuclear force.

Peculiarities of nuclear force

- Short range force
- When the distance between the nucleons is far from a particular distance the force is zero and if the distance is less the force is repulsive.
- Does not depend on electric charge
- Nuclear force is the same between a proton and a proton, a proton and a neutron and also between neutrons.

6.09 Nuclear energy

You know that in the nucleus of an atom energy exists as binding energy. If so isn't it possible to use this energy to meet our increasing needs and to solve energy crisis?

Nuclear energy is released in two ways

- Nuclear fission
- Nuclear fusion

6.10 Nuclear fission

Nuclear fission was discovered by the two scientist Otto Hahn and Strassmann. The nuclear reaction, when a Uranium 235 nucleus is bombarded with a neutron is given below.

$$_0n^1 + {}_{92}U^{235} \qquad {}_{56}Ba^{141} + {}_{36}Kr^{92} + 3\,{}_0n^1 + \text{energy}$$

Carefully read through the formula and answer the following questions.

From this nuclear reaction

- What are the products of fission?
- How many neutrons are liberated?
- Is it a balanced equation?

Based on the above equation and the table 6.6, answer the following questions.

- What is the difference between the total masses before and after the nuclear reactions?

Mass before fission		Mass after fission	
Nucleus of one $_{92}U^{235}$	- 235.04393 u	Nucleus of one $_{56}Ba^{141}$	140.9177u
One Neutron	1.00866u	Nucleus of one $_{36}Kr^{92}$	91.8854 u
		3 Neutrons	3.02598u
Total	236.05259u	**Total**	235.82908

Table 6.6

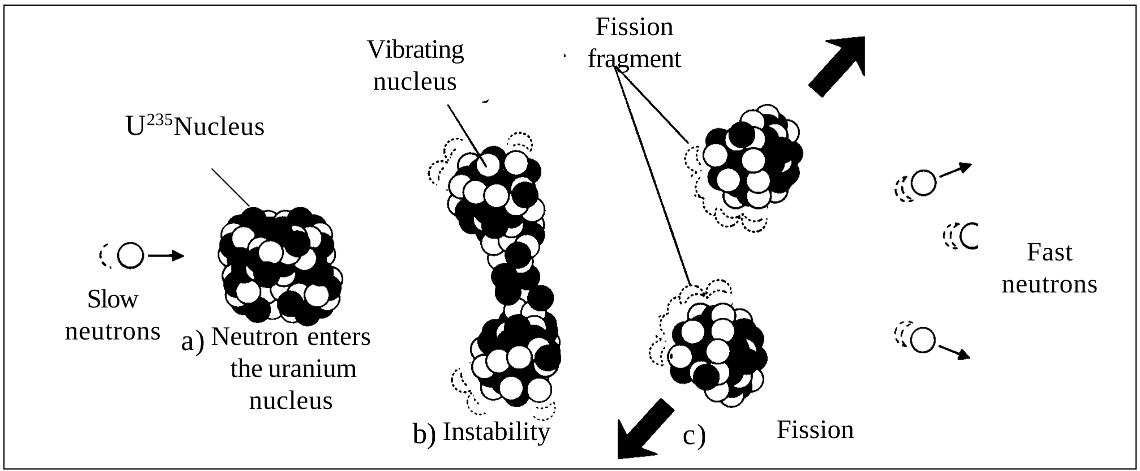


figure 6.6
Fission of U^{235} nucleus

- What happens to the lost mass?
- In the above reaction the nucleus $_{92}U^{235}$ is split into two and releases neutrons and energy. Explain with the help of table 6.6 how this released energy is generated.

Now let us formulate a definition of nuclear fission.

When a particle of sufficient energy is shot on to a heavier nucleus the nucleus splits and releases energy. This reaction is called nuclear fission.

6.11 Chain reaction

The processes going on in $_{92}U^{235}$ during fission is given in Fig 6.7

When a Uranium nucleus undergoes fission neutrons are released. These neutrons in turn split the surrounding uranium nuclei releasing neutrons in each fission (Fig 6.7). In this way the reaction continues. This is called chain reaction. This possibility was first stated by the scientist Enrico Fermi.

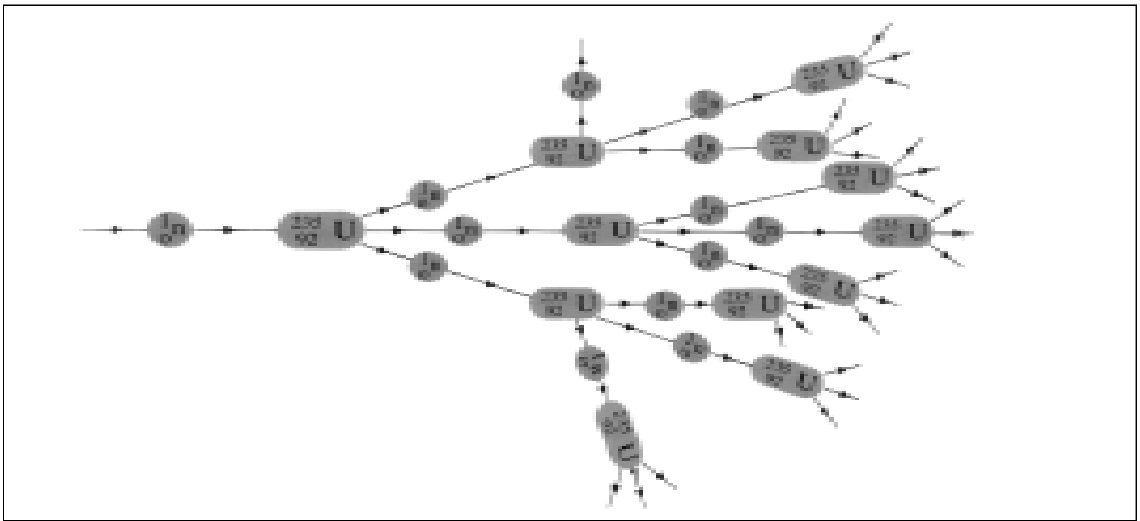


figure 6.7
Chain reaction

If this chain reaction is allowed to continue in an uncontrolled manner within a short span of time (One millionth of a second) there will be a release of enormous quantity of energy (about 2 10^{13}J) causing violent explosion. This is the principle of an atom bomb.

> **On August 6th 1945 a Uranium bomb was dropped on the city of Hiroshima killing 1.5 lakhs of people. After 3 days on August 9th another bomb was dropped in Nagasaki destroying the city and killing thousands of people. Those nuclear bombs had only a strength equivalent to about 20,000 tonnes TNT.**

6.12 Nuclear reactor

Can we control chain reaction? If we can, we can produce energy to suit our energy needs. It has became possible today.

A device that is used to produce nuclear energy by controlled nuclear fission is called a nuclear reactor.

Nuclear reactors are used not only for the production of energy but also for research purposes. There are different types of reactors based on functional and structural differences. However the following parts are common to all types of reactors.

- **Reactor Core:** The part of the reactor where fuel is kept.
- **Fuels:** The fuels commonly used are U^{235}, Plutonium (Pu^{239}), Uranium (U^{233}).
- **Source of neutrons:** A mixture of Beryllium powder and Polonium are the source of neutrons.
- **Moderator**

The neutrons released in the reactor are fast neutrons. So in U^{235} the possibility of fission is less. Therefore, to increase the rate of fission, neutrons have to be slowed down. Moderators are the materials used to slow

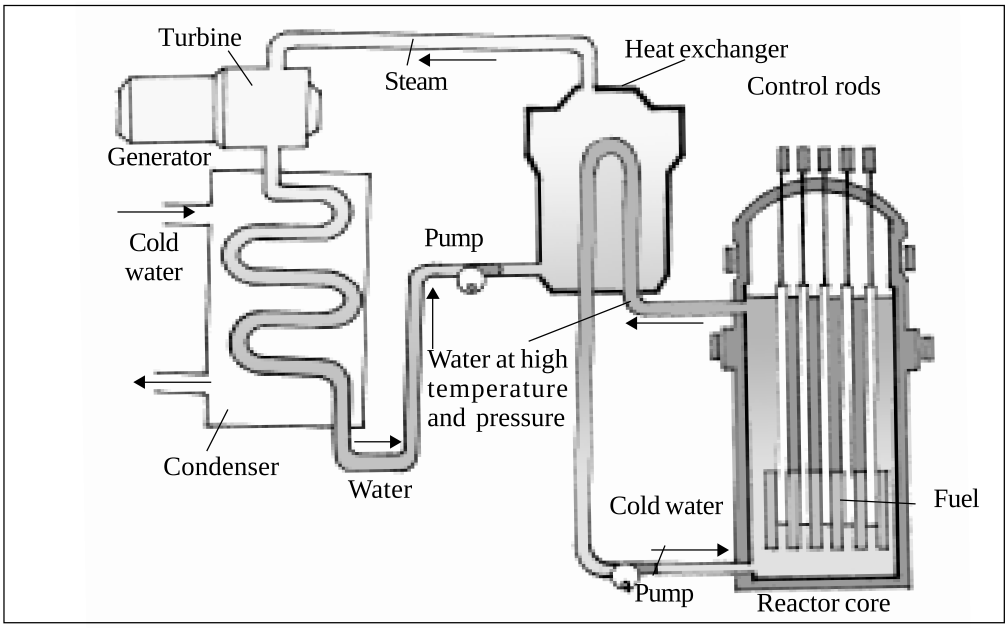


figure 6.8
Picture showing the structure of a nuclear reactor and generator

down the neutrons. Heavy water (D_2O), Graphite etc., are used as moderators.

- **Control rods**

We know that if we can control the speed of neutrons released during fission, chain reaction will take place. If the number of neutrons produced is uncontrolled, huge amount of energy will be suddenly produced. In the same way if more neutrons than is necessary to sustain the chain reaction is absorbed, the reactor will cease to function. Therefore by controlling the number of neutrons in a reactor chain reaction can be controlled. Some rods like boron, cadmium etc. are used to control this and they are called control rods.

- **Shield to protect radiation**

During nuclear fission dangerous radiations like gamma rays are formed. In order to protect living things from radiation some shields made of thick lead and concrete are used around the core and the reactor.

- **Coolants**

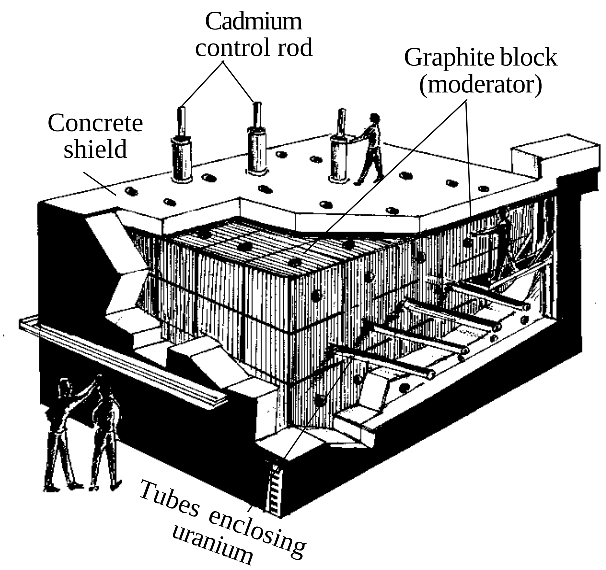


figure 6.9
The central portion of the reactor containing nuclear fuel

As a result of fission reaction a lot of heat is generated. This heat is taken out of the core by some fluids like high pressure water, liquid metals and gases. They are called coolants.

Some reactors will produce energy as well as nuclear fuels like Pu^{239}. Such reactors are called fast breeder reactor. At Kalpakkam in Tamil nadu there is a fast breeder reactor.

6.13 Nuclear fusion

We have already seen that energy can be released by the fission of heavy nucleus. Similarly energy can be liberated by the fusion of light nucleus also.

Deuterium is a hydrogen isotope with mass number 2. At very high temperature Deuterium nuclei with high kinetic energy fuse to form Helium nuclei and in this process a lot of energy is released. As very high temperature is required for this reaction we call this thermonuclear reaction.

The process of merging two or more light nuclei to form a heavier nucleus is called nuclear fusion. A large quantity of energy is liberated during this nuclear fusion. In stars including the sun energy is released through the process of nuclear fusion.

Complete the table below after studying the differences between fission and fusion.

Fission	Fusion
• Fuel is scarce	• Fuel is plenty
• High temperature is not necessary	• Extremely high temperature is necessary
• Very fast reaction	• Occurs in different stages
•	•

Table 6.7

6.14 Nuclear research in India

Under the leadership of Dr. Homi.J Bhabha in 1945 the atomic research programme commenced in India in the Tata Institute of Fundamental Research (TIFR).

The following are the aims of our atomic research

- Generation of electricity
- Production of radioisotopes
- Industrial development
- Agricultural development
- Promotion of research

Homi Jahangheer Bhabha (1909-1966)

Born in a rich Parsi family in Mumbai on October 30, 1909. When he was in London for his studies he got an opportunity to work along with outstanding scientists like Enrico Fermi, Wolf Gang Pauli and the like. He joined the Indian Institute of science in Bangalore. He was awarded fellowship of the royal society for his contribution to the fields of cosmic rays, fundamental particles, quantum mechanics etc.

At the initiative of Bhabha Tata Institute of Fundamental Research was established in 1945. In 1945 the Atomic energy commission came into being with Bhabha as its Chairman. Atomic reactors, like Apsara, Sirus, Serleena and a plant with enriched Uranium were started under his leadership. The contribution of H.J Bhabha in the field of atomic science helped our scientists to successfully conduct India's first atomic explosion in 1974 at Pokharan in Rajastan.

He died in a plane crash in the Alphs mountain during his foreign journey in 1966.

6.15 The consequences of radioactive radiation

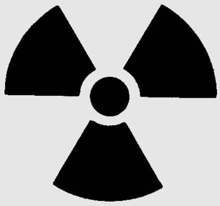
You have some knowledge about certain good uses of radioactive radiations. But it can also cause a lot of adverse consequences, as the radioactive radiations can penetrate through substances and ionize materials.

The following are the major hazards of radiations.

- Destroys living cells.
- Split protein molecules
- Gamma radiations cause genetic mutation in DNA molecules.
- Causes cancer
- Results in genetic deformities
- Destroys biodiversity

Discuss and prepare notes on how to overcome the harmful effects of radiations.

Even though harmful effects of radiation are numerous, scientists believe that this is one of the several means of combating the energy crises in the world if used cautiously and in a controlled manner.



International symbol that warns of the harmful effects of radiation

Symbol on the food materials sterilized by radiations.

Atomic reactors in India

Date of commencement	Reactor	State	Main features
4 August 1956	Apsara	Trombay-Mumbai	Research Reactor
10 July1960	Sairus	”	Research Reactor
14 January 1961	Serleena	”	Research Reactor
2 October 1969	Tharapoor	Maharastra	Power station
18 May 1972	Poornima -I	Trombay-Mumbai	Research Reactor
30 November 1972	Kotta -unit I	Rajastan	Power station
1 November1980	Kotta -unit II	Rajastan	Power station
27 January1984	Kalpakkam-I Madras Power Station	Tamil Nadu	Power station
10 May 1984	Poornima-II	Trombay-Mumbai	Research reactor U-233
8August1985	Dhruva	Trombay-Mumbai	Research reactor
18 October 1985	Kalpakkam-I	Tamil Nadu	Fast breader Reactor
12 March 1986	Kalpakkam-II	Tamil Nadu	Power station
12 March 1989	Narora Unit-I	Uttar Pradesh	Power station
9 November 1990	Poornima-III	Trombay-Mumbai	Research reactor U-233
24 October 1991	Narora Unit-II	Uttar Pradesh	Power station
3 September 1992	Kakkrapar Unit- I	Gujarat	Power station
8 January 1995	Kakkrapar Unit- II	Gujarat	Power station
20 October 1996	Kalpakkom Mini reactor (Kamini)	Tamil Nadu	U-233
24 September 1999	Kaiga Unit-II	Karnataka	Power station
24 December 1999	Rajastan Unit III	Rajastan	Power station
26 September 2000	Kaiga Unit-I	Karnataka	Power station
3November 2000	Rajastan Unit IV	Rajastan	Power station

Summary

- **Isobar:** Atoms of different elements having the same mass number.
- **Radioactivity:** When the neutron - proton ratio of an element is not in a certain limit, the nucleus undergoes decay emitting energy.
- **Alpha, Beta, Gamma radiation:** Alpha, Beta and Gamma are the three radiations in natural radioactivity.
- **Half life period:** The time period required for a radioactive isotope to disintegrate itself to half its initial mass.
- **Radioisotopes:** Used in industry, medicine research etc.
- **Mass defect:** The difference between the total mass of the particles in an atom and the rest mass of the atom.
- **Binding energy:** The mass defect converts itself into energy. This energy binds the nucleons in a nucleus.
- **Nuclear fission:** Spliting of heavy atoms liberating energy.
- **Nuclear fusion :** Merging of light nuclei liberating energy.
- **Chain reaction:** Continuous nuclear fission. A nuclear reaction in which nuclear fission is induced by a neutron which in turn causes further fission.
- **Nuclear reactor:** A device that is used to produce nuclear energy by controlled nuclear fission.
- **Breeder reactor:** A device that is used to produce atomic energy as well as nuclear fuel.
- **Harmful effects of nuclear radiations:** Causes destruction of living cells, spliting of protein molecules, genetic mutation in DNA molecules causes cancer, destruction of biodiversity.

More activities for you

1. Complete the table given below

Number	Elements	Mass of nucleus	Total mass of particles	Mass defect (m)	Binding energy $E = mc^2$
1	Lithium	6.939			
2	Fluorine	18.998			
3	Carbon	12.01			
4	Calcium	40.08			

Mass of Proton = 1.007276u

Mass of Neutron = 1.008665u

2. Construct a model of chain reaction using LED.
3. Arrange an exhibition of photographs of nuclear reactors.
4. Conduct a seminar about different types of reactors, their structure and their functions.
5. Conduct discussions on
   - Nuclear reactors and energy crisis in Kerala
   - Can we solve the energy crisis by setting up more nuclear reactors in countries facing energy crisis.
6. Exhibit a poster against the making of atomic weapons, their use so as to create an awareness about its harmful effects.
7. Prepare letters addressed to the Presidents of countries possessing atomic weapons and exhibit the same in your bulletin board.
8. Collect pictures and paper cuttings relating to the disasters caused by atomic radiation.
9. Prepare a note regarding the various atomic experiments in recent years in India.