# Chapter 6
# Nuclear Physics

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## I. Choose the correct Answer.

**Question** 1.
Man-made radioactivity is also known as;
(a) Induced radioactivity
(b) Spontaneous radioactivity
(c) Artificial radioactivity
(d) (a) and (c)
**Answer**:
(a) Induced radioactivity

**Question** 2.
Unit of radioactivity is ____.
(a) roentgen
(b) curie
(c) becquerel
(d) all the above.
**Answer**:
(d) all the above.

**Question** 3.
Artificial radioactivity was discovered by:
(a) Becquerel
(b) Irene Curie
(c) Roentgen
(d) Neils Bohr
**Answer**:
(b) Irene Curie

**Question** 4.
In which of the following, no change in mass number of the daughter nuclei takes place ____.
(i) α decay
(ii) β decay
(iii) γ decay
(iv) neutron decay
(a) (i) is correct
(b) (ii) and (iii) are correct
(c) (i) & (iv) are correct
(d) (ii) & (iv) are correct.

**Answer**:
(b) (ii) and (iii) are correct

**Question** 5.
……. isotope is used for the treatment of cancer.
(a) Radio Iodine
(b) Radio Cobalt
(c) Radio Carbon
(d) Radio Nickel
**Answer**:
(b) Radio Cobalt

**Question** 6.
Gaming radiations are dangerous because of _____.
(a) it affects eyes & bones
(b) it affects tissues
(c) it produces genetic disorder
(d) it produces an enormous amount of heat.
**Answer**:
(c) it produces genetic disorder

**Question** 7.
……. aprons are used to protect us from gamma radiations.
(a) Lead oxide
(b) Iron
(c) Lead
(d) Aluminium
**Answer**:
(c) Lead

**Question** 8.
Which of the following statements is/are correct?
(i) a particles are photons.
(ii) Penetrating power of γ radiation is very low.
(iii) Ionization power is maximum for a rays.
(iv) Penetrating power of γ radiation is very high.
(a) (i) & (ii) are correct
(b) (ii) & (iii) are correct
(c) (iv) only correct
(d) (iii) & (iv) are correct
**Answer**:
(d) (iii) & (iv) are correct

**Question** 9.
Proton-Proton chain reaction is an example of _____.
(a) Nuclear fission

(b) α – decay
(c) Nuclear fusion
(d) β – decay.
**Answer**:
(c) Nuclear fusion

**Question** 10.
In the nuclear reaction $_{6}X^{12} \xrightarrow{\alpha \text{ decay}} {}_{Z}Y^{A},$ the value of A and Z.
(a) 8, 6
(b) 8, 4
(c) 4, 8
(d) cannot be determined with the given data
**Answer**:
(b) 8, 4

**Question** 11.
Kamini reactor is located at:
(a) Kalpakkam
(b) Koodankulam
(c) Mumbai
(d) Rajasthan
**Answer**:
(a) Kalpakkam

**Question** 12.
Which of the following is/are correct?
(i) Chain reaction takes place in a nuclear reactor and an atomic bomb.
(ii) The chain reaction in a nuclear reactor is controlled
(iii) The chain reaction in a nuclear reactor is not controlled
(iv) No chain reaction takes place in an atom bomb
(a) (i) only correct
(b) (i) & (ii) are correct
(c) (iv) only correct
(d) (iii) & (iv) are correct.
**Answer**:
(b) (i) & (ii) are correct

## II. Fill in the blanks.

1. One roentgen is equal to …… disintegrations per second.
2. Positron is an ……
3. Aneamia can be cured by …… isotope.
4. Abbreviation of ICRP ……..
5. …… is used to measure exposure rate of radiation in humans.

6. ……. has the greatest penetration power.
7. ${}_{Z}Y^{A} \rightarrow {}_{Z+1}Y^{A} + X$; Then, X is ……..
8. ${}_{Z}X^{A} \rightarrow {}_{Z}Y^{A}$ This reaction is possible in …….. decay.
9. The average energy released in each fusion reaction is about …….. J.
10. Nuclear fusion is possible only at an extremely high temperature of the order of ……. K.
11. The radio isotope of …….. helps to increase the productivity of crops.
12. If the radiation exposure is 100 R, it may cause ……..

**Answer**:
1. $1.6 \times 10^{15}$ disintegrations / second
2. antiparticle $[{}_{1}e^{0}]$
3. Radio iron $Fe^{59}$
4. International Commission on Radiological Protection
5. Dosimeter
6. Gama rays
7. X is ${}_{-1}e^{0}$
8. gamma
9. $3.84 \times 10^{12}$ J
10. $10^{7}$ to $10^{9}$ K
11. Radio phosphorus P – 32
12. fatal diseases like leukemia.

## III. State whether the following statements are true or false: If false, correct the statement.

1. Plutonium -239 is a fissionable material.
2. Elements having atomic number greater than 83 can undergo nuclear fusion.
3. Nuclear fusion is more dangerous than nuclear fission.
4. Natural uranium U-238 is the core fuel used in a nuclear reactor.
5. If a moderator is not present, then a nuclear reactor will behave as an atom bomb.
6. During one nuclear fission on an average, 2 to 3 neutrons are produced.
7. Einstein's theory of mass energy equivalence is used in nuclear fission and fusion.

**Answer**:
1. True
2. False – Elements having atomic number greater than 83 can undergo nuclear fission.
3. True
4. False – Natural U – 238 not used as fuel in a nuclear reactor.
5. True
6. True
7. True

## IV. Match the following.

**Question** 1.
Match the column I with column II.

| Column I | | Column II | |
|---|---|---|---|
| (a) | BARC | (i) | Kalpakkam |
| (b) | India's first atomic power station | (ii) | Apsara |
| (c) | IGCAR | (iii) | Mumbai |
| (d) | First nuclear reactor in India | (iv) | Tarapur |

**Answer**:
(a) – (iii)
(b) – (i)
(c) – (iv)
(d) – (ii)

**Question** 2.
Match the column I with column II.

| Column I | | Column II | |
|---|---|---|---|
| (a) | Fuel | (i) | lead |
| (b) | Moderator | (ii) | heavy water |
| (c) | Coolant | (iii) | cadmium rods |
| (d) | Shield | (iv) | uranium |

**Answer**:
(a) – (iv)
(b) – (ii)
(c) – (iii)
(d) – (i)

**Question** 3.
Match the column I with column II.

| Column I | | Column II | |
|---|---|---|---|
| (a) | Soddy Fajan | (i) | Natural radioactivity |
| (b) | Irene Curie | (ii) | Displacement law |
| (c) | Henry Becquerel | (iii) | Mass energy equivalence |
| (d) | Albert Einstein | (iv) | Artificial Radioactivity |

**Answer**:
(a) – (ii)
(b) – (iv)
(c) – (i)
(d) – (iii)

**Question** 4.
Match the column I with column II.

| Column I | | Column II | |
|---|---|---|---|
| *(a)* | Uncontrolled fission reaction | *(i)* | Hydrogen Bomb |
| *(b)* | Fertile material | *(ii)* | Nuclear Reactor |
| *(c)* | Controlled fission reaction | *(iii)* | Breeder reactor |
| *(d)* | Fusion reaction | *(iv)* | Atom bomb |

**Answer**:
(a) – (iv)
(b) – (iii)
(c) – (ii)
(d) – (i)

**Question** 5.
Match the column I with column II.

| Column I | | Column II | |
|---|---|---|---|
| *(a)* | Co - 60 | *(i)* | Age of fossil |
| *(b)* | I - 131 | *(ii)* | Function of Heart |
| *(c)* | Na -11 | *(iii)* | Leukemia |
| *(d)* | C - 14 | *(iv)* | Thyroid disease |

**Answer**:
(a) – (iii)
(b) – (iv)
(c) – (ii)
(d) – (i)

## V. Arrange the following in the correct sequence.

**Question** 1.
Arrange in descending order, on the basis of their penetration power. Alpha rays, beta rays, gamma rays, cosmic rays
**Answer**:
gamma rays < beta rays < alpha rays < cosmic rays.

**Question** 2.
Arrange the following in the chronological order of discovery.
Nuclear reactor, radioactivity, artificial radioactivity, discovery of radium.
**Answer**:
Discovery of radium, Radioactivity, Artifical radioactivity, Nuclear reactor.

## VI. Use the analogy to fill in the blank.

1. Spontaneous process : Natural Radioactivity, Induced process : ……..
2. Nuclear Fusion : Extreme temperature, Nuclear Fission : ……..
3. Increasing crops : Radio phosphorous, Effective functioning of heart : ……
4. Deflected by electric field : a ray, No Deflection : ……..

**Answer**:

1. artifical radioactivity
2. higher temperature
3. Radio sodium
4. γ-ray

## VII. Numerical problems.

**Question** 1.
$_{88}Ra^{226}$ experiences three a – decay. Find the number of neutrons in the daughter element.
**Answer**:
Mass number of $_{88}Ra^{226}$ is 266
Atomic number of $_{88}Ra^{226}$ is 88
Mass number of $\alpha = 4$
Atomic number of $\alpha = 2$
After 3 a decay
Mass number of the daughter element is
$= 266 - (3 \times 4)$
$= 266 - 12$
$= 254$
Atomic number of the daughter element is
$= 88 - (3 \times 2)$
$= 88 - 6$
$= 82$
Number of neutrons is
$= 254 - 82$
$= 172$

**Question** 2.
A cobalt specimen emits induced radiation of 75.6 millicurie per second. Convert this disintegration in to becquerel (one curie $= 3.7 \times 10^{10}$ Bq).
**Answer**:
1 curie $= 3.7 \times 10^{10}$ Bq
$\therefore 75.6 \times 10^{-3}$ curie $= 75.6 \times 10^{-3} \times 3.7 \times 10^{10}$
$= 279.72 \times 10^{7}$ Bq
$= 279.72 \times 10^{7}$ Becquerel

## VIII. Assertion and reason type Questions.

**Question** 1.
Assertion: A neutron impinging on $U^{235}$, splits it to produce Barium and Krypton.
Reason: U – 235 is a fissile material.
(a) If both the assertion and the reason are true and the reason is the correct explanation of the assertion.
(b) If both the assertion and the reason are true, but the reason is not the correct explanation of the assertion.
(c) If the assertion is true, but the reason is false.
(d) If the assertion is false, but the reason is true.
**Answer**:
(a) If both the assertion and the reason are true and the reason is the correct explanation of the assertion.

**Question** 2.
Assertion: In a 3 – decay, the neutron number decreases by one.
Reason: In 3 – decay atomic number increases by one.
(a) If both the assertion and the reason are true and the reason is the correct explanation of the assertion.
(b) If both the assertion and the reason are true, but the reason is not the correct explanation of the assertion.
(c) If the assertion is true, but the reason is false.
(d) If the assertion is false, but the reason is true.
**Answer**:
(a) If both the assertion and the reason are true and the reason is the correct explanation of the assertion.

**Question** 3.
Assertion: Extreme temperature is necessary to execute nuclear fusion.
Reason: In a nuclear fusion, the nuclei of the reactants combine releasing high energy.
(a) If both the assertion and the reason are true and the reason is the correct explanation of the assertion.
(b) If both the assertion and the reason are true, but the reason is not the correct explanation of the assertion.
(c) If the assertion is true, but the reason is false.
(d) If the assertion is false, but the reason is true.
**Answer**:
(b) If both the assertion and the reason are true, but the reason is not the correct explanation of the assertion.

**Question** 4.
Assertion: Control rods are known as 'neutron seeking rods'.
Reason: Control rods are used to perform sustained nuclear fission reaction.
(a) If both the assertion and the reason are true and the reason is the correct explanation of

the assertion.
(b) If both the assertion and the reason are true, but the reason is not the correct explanation of the assertion.
(c) If the assertion is true, but the reason is false.
(d) If the assertion is false, but the reason is true.
**Answer**:
(a) If both the assertion and the reason are true and the reason is the correct explanation of the assertion.

## IX. Answer in one or two words (VSA).

**Question** 1.
Who discovered natural radioactivity?
**Answer**:
Henri Becquerel

**Question** 2.
Which radioactive material is present in the ore of pitchblende?
**Answer**:
Uranium is the radioactive material is present in the ore of pitchblende.

**Question** 3.
Write any two elements which are used for inducing radioactivity?
**Answer**:
Boron and aluminium

**Question** 4.
Write the name of the electromagnetic radiation which is emitted during natural radioactivity.
**Answer**:
Gamma rays are the electromagnetic radiation which is emitted during natural radioactivity.

**Question** 5.
If A is a radioactive element which emits an α – particle and produces $_{104}Rf^{259}$. Write the atomic number and mass number of the element A.
**Answer**:
$$_{Z}X^{A} \xrightarrow{\alpha} {}_{104}Rf^{259}$$
Mass number A = 259 + 4 = 263
Atomic number Z = 104 + 2 = 106

**Question** 6.
What is the average energy released from a single fission process?
**Answer**:
200 MeV

**Question** 7.
Which hazardous radiation is the cause for the genetic disease?
**Answer**:
γ – ray (Gamma-ray) or any high energy nuclear particle passes through a human being, it disrupts the entire normal functioning of the biological system and the effect may be an either pathological or genetic disease.

**Question** 8.
What is the amount of radiation that may cause death of a person when exposed to it?
**Answer**:
600 R.

**Question** 9.
When and where was the first nuclear reactor built?
**Answer**:
The first nuclear reactor was built in 1942 at Chicago, USA.

**Question** 10.
Give the SI unit of radioactivity.
**Answer**:
The SI unit of radioactivity is becquerel.

**Question** 11.
Which material protects us from radiation?
**Answer**:
Lead

## X. Answer the following Questions in a few sentences.

**Question** 1.
Write any three features of natural and artificial radioactivity.
**Answer**:

| S.No. | Natural radioactivity | Artificial radioactivity |
|---|---|---|
| 1 | Emission of radiation due to self-disintegration of a nucleus. | Emission of radiation due to disintegration of a nucleus through induced process. |
| 2 | Alpha, beta and gamma radiations are emitted. | Mostly elementary particles such as neutron, positron, etc. are emitted. |
| 3 | It is a spontaneous process. | It is an induced process. |

| | | |
|---|---|---|
| 4 | Exhibited by elements with atomic number more than 83. | Exhibited by elements with atomic number less than 83. |
| 5 | This cannot be controlled. | This can be controlled. |

**Question** 2.
Define critical mass.
**Answer**:
The minimum mass of fissile material necessary to sustain the chain reaction is called 'critical mass ($m_c$)'. It depends on the nature, density and the size of the fissile material.

**Question** 3.
Define one roentgen.
**Answer**:
One roentgen is defined as the quantity of radioactive substance which produces a charge of $2.58 \times 10^{-4}$ coulomb in 1 kg of air under standard conditions of pressure, temperature and humidity.

**Question** 4.
State Soddy and Fajan's displacement law.
**Answer**:
(i) When a radioactive element emits an alpha particle, a daughter nucleus is formed whose mass number is less by 4 units and the atomic number is less by 2 units, than the mass number and atomic number of the parent nucleus.

(ii) When a radioactive element emits a beta particle, a daughter nucleus is formed whose mass number is the same and the atomic number is more by 1 unit, than the atomic number of the parent nucleus.

**Question** 5.
Give the function of control rods in a nuclear reactor.
**Answer**:
Control rods are used to control the number of neutrons in order to have a sustained chain reaction. Mostly boron or cadmium rods are used as control rods. They absorb the neutrons.

**Question** 6.
In Japan, some of the newborn children are having congenital diseases. Why?
**Answer**:
In Japan, there was a leakage of nuclear radiations in some areas. In those areas, if the new born children handled with careless they are exposed to harmful radiations then they have congenital diseases.

**Question** 7.
Mr. Ramu is working as an X – ray technician in a hospital. But, he does not wear the lead aprons. What suggestion will you give to Mr. Ramu?
**Answer**:
The intensity of X-rays is very low. So, X-rays do not produce any severe effects. There are certains clothes that can be used while operating X-ray machines. Ramu can use them and so he may not be severely affected by X-rays, he should avoid eating and drinking when he is working with X-rays.

**Question** 8.
What is stellar energy?
**Answer**:
Fusion reaction that takes place in the cores of the Sun and other stars results in an enormous amount of energy, which is called stellar energy.

**Question** 9.
Give any two uses of radio isotopes in the field of agriculture?
**Answer**:
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.

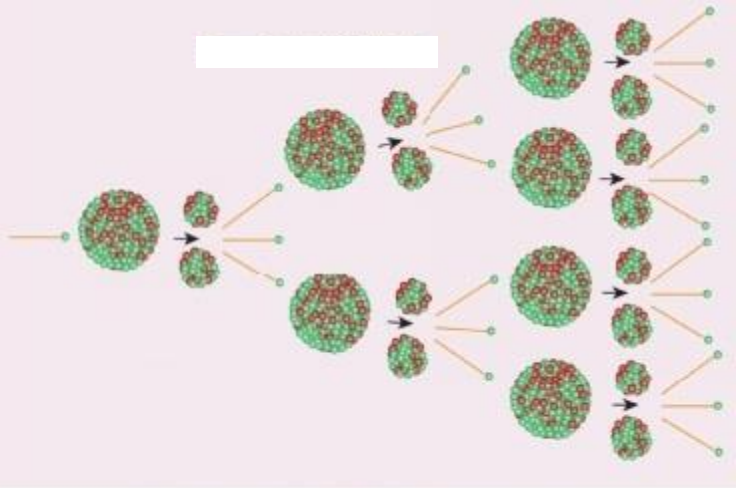
**Question** 10.
What is stellar energy?
**Answer**:
Fusion reaction that takes place in the cores of the Sun and other stars results in an enormous amount of energy, which is called as stellar energy.

## XI. Answer the following Questions in detail.

**Question** 1.
Explain the process of controlled and uncontrolled chain reactions.
**Answer**:
(i) Controlled chain reaction: In the controlled chain reaction the number of neutrons released is maintained to be one. This is achieved by absorbing the extra neutrons with a neutron absorber leaving only one neutron to produce further fission. Thus, the reaction is sustained in a controlled manner. The energy released due to a controlled chain reaction can be utilized for constructive purposes. Controlled chain reaction is used in a nuclear reactor to produce energy in a sustained and controlled manner.

(ii) Uncontrolled chain reaction: In the uncontrolled chain reaction the number of neutrons multiplies indefinitely and causes fission in a large amount of the fissile material. This results in the release of a huge amount of energy within a fraction of a second. This kind of

chain reaction is used in the atom bomb to produce an explosion.



Uncontrolled chain reaction

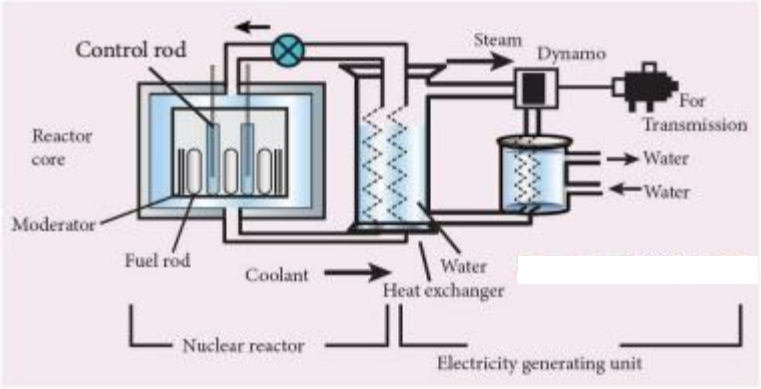
**Question** 2.
Compare the properties of alpha, beta and gamma radiations.
**Answer**:

| Properties | α rays | β rays | γ rays |
|---|---|---|---|
| What are they? | Helium nucleus ($_2He^4$) consisting of two protons and two neutrons. | They are electrons ($_{-1}e^0$), basic elementary particle in all atoms. | They are electromagnetic waves consisting of photons. |
| Charge | Positively charged particles. Charge of each alpha particle = +2e | Negatively charged particles. Charge of each beta particle = –e | Neutral particles. Charge of each gamma particle = zero |
| Ionising power | 100 time greater than β rays and 10,000 times greater than γ rays | Comparatively low | Very less ionization power |
| Penetrating power | Low penetrating power (even stopped by a thick paper) | Penetrating power is greater than that of α rays. They can penetrate through a thin metal foil. | They have a very high penetrating power greater than that of β rays. They can penetrate through thick metal blocks. |
| Effect of electric and magnetic field | Deflected by both the fields. (in accordance with Fleming's left hand rule) | Deflected by both the fields; but the direction of deflection is opposite to that for alpha rays. (in accordance with Fleming's left hand rule) | They are not deflected by both the fields. |
| Speed | Their speed ranges from 1/10 to 1/20 times the speed of light. | Their speed can go up to 9/10 times the speed of light. | They travel with the speed of light. |

**Question** 3.
What is a nuclear reactor? Explain its essential parts with their functions.
**Answer**:
A Nuclear reactor is a device in which the nuclear fission reaction takes place in a self-sustained and controlled manner to produce electricity.
Components of a nuclear reactors:
The essential components of a nuclear reactor are

1. fuel,
2. moderator,
3. control rod,
4. coolant and
5. protection wall.

1. Fuel : A fissile material is used as the fuel. The commonly used fuel material is uranium.
2. 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
3. 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.
4. Coolant : A coolant is used to remove the heat produced in die 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.
5. 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.




## XII. HOT Questions.

**Question** 1.
The mass number of a radioactive element is 232 and its atomic number is 90. When this element undergoes certain nuclear reactions, it transforms into an isotope of lead with a mass number 208 and an atomic number 82. Determine the number of alpha and beta decay that can occur.
**Answer**:

$_{90}X^{232} \xrightarrow{4\beta} 94Y^{232} + 4_{-4}e^{0}$ (4β decay)

From the result of β decay,

$94^{232} \xrightarrow{6\alpha} 82Pb^{208} + 6He^{4}$ (6α decay)

The number of α decay = 6

The number of β decay = 4.

**Question** 2.
'X – rays should not be taken often'. Give the reason.
**Answer**:
X-rays have some low intensity. Even then if a person undergoes the exposure of X-ray, his skin may be affected. The tissues near by the bones may be damaged.

**Question** 3.
Cell phone towers should be placed far away from the residential area – why?
**Answer**:
From the cell phone towers micro-waves are scattered for a particular area. This may affect small children and aged people. If people are exposed with those rays very often then they may be severly affected.