Nuclear Physics

Exercise-1

Question 1.
Give at least two differences between a chemical change and nuclear change.
Answer:
Chemical change

1. Change in number of orbital electrons takes place.
2. Requires energy of few eV for a chemical reaction to take place.
3. Number of atoms of each kind is conserved in reactants and products

Nuclear change

1. Change in number of nucleons takes place.
2. Nuclear change require much higher energy of the order of 10^6 times as compared to chemical change.
3. Atomic number and mass number is conserved.

Question 2.
State Rutherford and Soddy's Laws of natural radioactive decay for
(1) alpha emission
(2) beta emission.
Answer:
(1) Rutherford and Soddy's Law of Alpha Emission : "When a radio-active nuclide ejects on alpha particle (α) i.e. ^4_2H, its mass number decreases by 4 and atomic number decreases by 2 such that the position of daughter nuclide is two places behind in the predictable as compared to the parent nuclide ?

$$ {}_ZX^A \xrightarrow[-\alpha]{} {}_{Z-2}Y^{A-4} + {}_2He^4 $$

e.g. $^{238}_{92}U \xrightarrow[-\alpha]{} ^{234}_{90}Th + ^4_2He$

(2) Rutherford and Soddy's Law of Beta Emission : "When a radio-active nuclide ejects a beta particle, its mass number remain Unaffected but Atomic Number Increases by one such that the position of the daughter nuclide is one place Ahead in the periodic table as compared to the parent nuclei." The daughter product is Isobar.

$$ {}^A_ZX \xrightarrow{-\beta} {}^A_{Z+1}Y + {}^0_{-1}e $$

e.g. $^{24}_{11}Na \xrightarrow{-\beta} {}^{24}_{12}Mg + {}^{0}_{-1}e$

$^{14}_{6}C \xrightarrow{-\beta} {}^{14}_{7}N + {}^{0}_{-1}e$

Question 3.

Thorium isotope $^{223}_{90}Th$ undergoes two successive β-decays. Find the mass number and atom C number after the decay. Also represent the above decays in the form of a nuclear equation.

Answer:

After first p decay mass number remains same i.e. 223 but Atomic number increases by 1 and becomes 91

$^{223}_{90}Th \xrightarrow{-\beta} {}^{223}_{91}Th + {}^{0}_{-1}e$

Two successive P radiations cannot take place. He a radiation takes place which does not change mass number or atomic number.

Now second β decay

$^{223}_{91}Th_1 \xrightarrow{-\beta} {}^{223}_{92}Th_2 + {}^{0}_{-1}e$

mass number remains 223 atomic number becomes 92.

Question 4.

How is the ionising and penetrating powers of α, β and γ radiations compared with each other ?

Answer:

Comparison of Ionising power of α, β,γ Heavier particle has high ionising power.

a → 10,000 times of α and 100 times of β

P → 100 times of α

∴ Maximum ionising power a, minimum ionising power γ.

Comparison of Penetrating power of α, β and γ

Light particle has maximum speed hence maximum penetrating power.

α has very large penetrating power up to a few hundred meter in air.

α has small penetrating power (being very heavy) 3 to 8 cm in air

β- has large penerating power up to few meter in air α < β < γ.

Question 5.

When does the nucleus of an atom tend to be radioactive?

Answer:

Nucleus of an atom become radio-active when increase in nuclear force.

PACE WITH INCREASE IN THE REPULSIVE FORCE :

i.e.when there are too many neutrons compared to protons or too many protons compared to neutrons in the nucleus of atom. Or The nucleus of the atom becomes radioactive if it is a radio-isotope, i.e. number of neutrons in the nucleus exceeds the

number of protons inside it.

For example :

$^{60}_{27}Co, ^{14}_{6}C$ (Z = 6, A = 14), $^{40}_{19}K$ (Z = 19, A = 40)

Question 6.

Radioactive sodium $^{24}_{11}Na$ changes to stable $^{24}_{12}Th$ Which particle does it eject ?

Answer:

P-particle ($^{0}_{-1}e$)

∴ There is no change in mass number but atomic number of daughter nucleus magnesium increases by one.

Question 7.

A radioactive element $^{A}_{Z}X$ loses two successive β-particles and then an alpha particle, such that the resulting nuclide $^{P}_{Q}Y$ is Calculate the values of P and Q.

Answer:

$$^{A}_{Z}X \xrightarrow{-\beta} {}^{A}_{Z+1}Y \xrightarrow{-\beta} {}^{A}_{Z+2}Z$$

When $^{A}_{Z}X$ loses first β-particle atomic number of daughter nucleus Y increases by one and mass number remains the same

$$^{A}_{Z}X \xrightarrow{-\beta} {}^{A}_{Z+1}Y + {}^{0}_{-1}e$$

When $^{A}_{Z+1}X$ loses another β-particle changes to daughter nucleus Z and atomic number again increases by one and mass number still remains the same A.

$$^{A}_{Z+1}Y \xrightarrow{-\beta} {}^{A}_{Z+1}Z + {}^{0}_{-1}e$$

Or

$$^{A}_{Z}X \xrightarrow{-2\beta} {}^{P}_{Q}Y - 2{}^{0}_{-1}e$$

$$\therefore \ ^{P}_{Q}Y \Rightarrow {}^{A}_{Z+2}Y \qquad \therefore \ P = A$$

$$Q = Z + 2$$

Question 8.

(a) An imaginary radioactive particle $^{235}_{92}X$ decays to form elements X_1, X_2, X_3, X_4, X_5 and X_6 by ejecting 2 beta particles, followed by an alpha particle and again 2 beta particles followed by an alpha particle. Represent the above in the form of nuclear equations. What is the mass number of X_6 ?

(b) List the isotopes and isobars formed in the above nuclear reactions.

Answer:

(a) $^{235}_{92}X$ when α β particle is emitter mass number does not change but atomic number increases by 1 (isobar)

∴ When 2 successive β particles decay mass number does not change (isobar) but

atomic number increases by 2.
Then α-particle decays, mass number decreases by 4 and atomic number decreases by 2.
Ultimately when 2 β particles decays and la-particle decays

$$^{235-4}_{92+1+1-2}X$$

$$i.e.\ {}^{231}_{92}X_1 \text{ is produced.}$$

This means to change $^{235}_{92}X$ to $^{235}_{92}X_1$ here, atomic number remains same but mass number
decreases by 4
∴ In 6 steps [$X \rightarrow X_1 \rightarrow X_2 \rightarrow X_3 \rightarrow X_4 \rightarrow X_5 \rightarrow X_5$]
Atomic number remains same but mass number decreases by
6 x 4 = 24

$$\therefore\ {}^{235-24}_{92}X_6 \rightarrow {}^{211}_{92}X_6 \qquad \therefore \text{ mass number is } 211$$

Or

$$^{235}_{92}X \xrightarrow{-2\beta,-\alpha} {}^{231}_{92}X_1 \xrightarrow[-2\beta,-\alpha]{} {}^{227}_{92}X_2 \xrightarrow{-2\beta,-\alpha} {}^{223}_{92}X_3 \xrightarrow{-2\beta,-\alpha} {}^{219}_{92}X_4$$

$$\xrightarrow{-2\beta,-\alpha} {}^{215}_{92}X_5 \rightarrow {}^{211}_{92}X_6$$

(b) After every β decay isobar is formed and after α-decay isotope is formed
∴ Total 12 isobars and 6 isotopes are formed.

Question 9.
Give one example of nuclear fission.
Answer:
Nuclear power station is example of nuclear fission. Controlled chain reaction takes place and electricity is produced.

Question 10.
Indicate the missing particle in the following reaction :

$$^{235}_{92}U + {}^{1}_{0}n \longrightarrow {}^{139}_{56}Ba + (?) + 3{}^{1}_{0}n$$

Answer:

$$^{235}_{92}U + {}^{1}_{0}n \longrightarrow {}^{139}_{56}Ba + ({}^{94}_{36}Kr) + 3{}^{1}_{0}n$$

Question 11.

Complete the statement given below :

Splitting of nucleus into two nearly lighter nuclei is called

Answer:

Splitting of nucleus into two nearly lighter nuclei is called **nuclear fission.**

Question 12.

Name the fuel generally used in nuclear reactors.

Answer:

Enriched Uranium $^{235}_{92}U$ is used as fuel in nuclear reactor.

Question 13.

Give one example of a controlled and uncontrolled nuclear fission reaction.

Answer:

Example of:

1. Controlled nuclear fission reaction is to generate electricity in nuclear thermal plant.
2. Uncontrolled nuclear fission reaction is production of ATOM BOMB.

Question 14.

Name the isotopes of an element which are used in fusion

Answer:

ISOTOPES of ELEMENT HYDROGEN are :

$^{1}_{1}H$ protium

$^{2}_{1}H$ deuterium

$^{3}_{1}H$ Tritium

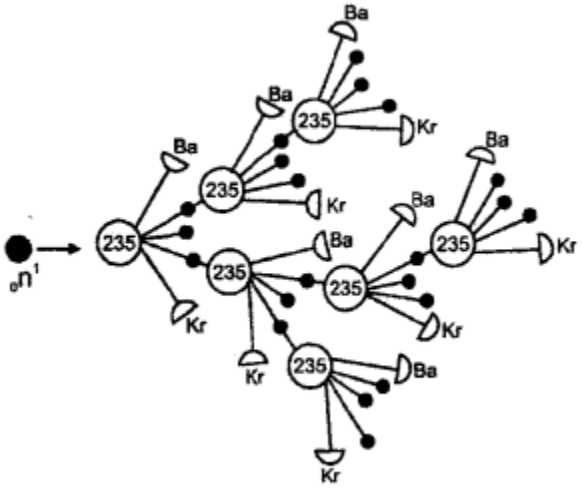
Question 15.

What is meant by nuclear chain reaction ? What happens, if this reaction goes out of control ?

Answer:

NUCLEAR CHAIN REACTION : A piece of URANIUM consists of millions of uranium atoms. When a slow moving neutron is bombarded, it produces three neutrons, if these neutrons are utilised to break further uranium atoms, 9 neutrons are produced and in this way a kind of chain reaction takes place with release of large amount of energy and

reaction becomes uncontrolled. This results in atom bomb.



Question 16.
The mass numbers of three elements A, B and C are 3, 180 and 235 respectively. Which one is suitable for making atomic bomb?
Answer:
Element C with atomic number 235 is suitable for making atom bomb.

Question 17(a).
Define nuclear fusion.
Answer:
NUCLEAR FUSION : The process of combining LIGHTER NUCLEI (Atomic weight less than 20) into heavier nuclei is called nuclear fusion

$$_1^2H + _1^2H \longrightarrow _1^3H + _1^1H + 88.2 \times 10^9\ J$$

$$_1^3H + _1^2H \longrightarrow _1^4He + _0^1n + 16.96 \times 10^{11}\ J$$

$$_1^1H \longrightarrow _2^4He + 2\,_{-1}^0e + \text{energy}$$

Question 17(b).
Which of the two, fission or fusion is a nuclear chain reaction?
Answer:
Fission is nuclear chain reaction.

Question 18.
Why can nuclear fusion and possible to generate electricity?
Answer:
It is not easy to start a fusion reaction as to fuse HYDROGEN atom minimum temperature of 1000000 °C is required which is not possible to create in laboratory. Controlled fusion reaction is not possible so far.

Question 19.
Give any two differences between nuclear fusion and nuclear fission.
Answer:
Nuclear Fusion

1. Two light nuclei fuse to form a heavy nucleus.
2. Cannot be controlled to generate electricity position.

Nuclear Fission

1. A heavy nucleus splits to form two smaller nuclei.
2. Can be controlled and is used to generate electricity.

Question 20.
Write nuclear equations for the fusion of
(a) 2 deuterium atoms
(b) one hydrogen and one tritium atom.
Answer:

(a) $${}_1^2H + {}_1^2H \longrightarrow {}_1^3H + {}_1^1H + 88.2 \times 10^9 \text{ J}$$

(b) $${}_1^3H + {}_1^2H \longrightarrow {}_1^4He + {}_0^1n + 16.96 \times 10^{11} \text{ J}$$

Multiple Choice Questions

Tick (✓) the most appropriate option.

1. The atoms of same element having same atomic number, but different atomic masses are called :
(a) isotopes
(b) isobars
(c) isotones
(d) both (a) and (b)

2. When an element gives out high energy radiations on its own, the change which takes place is :
(a) physical change
(b) chemical change
(c) nuclear change
(d) none of these

3. The atoms of different elements having same mass number, but different atomic numbers are called :
(a) isotopes
(b) isotones
(c) isobars
(d) none of these

4. The radiations given out by radioactive elements :
(a) affect photographic plates
(b) ionise the gases
(c) are affected by electrostatic and magnetic fields
(d) all of these

5. A radioactive substances emits :
(a) simultaneously α, β and γ radiations
(b) α-radiations or β-radiations
(c) in the order of α, β and γ particles
(d) X-rays and γ -rays

6. During α-emission :
(a) the mass number and atomic number of an atom decrease by 2 a mu.
(b) the mass number decreases by 4 amu and atomic number decreases by 2 amu.
(c) the mass number remains unchanged, but atomic number decreases by 2 amu.
(d) the mass number decreases by 4 amu and atomic number remains unchanged.

7. During β-emmision :
(a) the mass number remains unchanged, but atomic number increases by 1 amu.
(b) the mass number remains unchanged, but atomic number decreases by 1 amu.
(c) the mass number increases by 1 amu, but atomic number remains same.
(d) the mass number and atomic number decrease by 1 amu.

8. During β-emission an electron is ejected from the atom of radioactive substance. The electron is ejected from the:
(a) the outermost orbit of atom
(b) the innermost orbit of atom
(c) the nucleus of the atom
(d) none of these

9. Which of the following radiation is most ionising ?
(a) **α-particles**
(b) β-particles

(c) -radiation
(d) X-rays

10. Which of the following radiation is most penetrating ?
(a) α–particles
(b) β-particles
(c) Y -radiation
(d) X-rays

11. Which of the following radiation gets deflected most in electric or magnetic field ?
(a) α–particles
(b) β-particles
(c) Y -radiation
(d) X-rays

Questions From ICSE Examination Papers

2003

Question 1.
A small cube of lead is embedded in a big cube of aluminium metal It is placed in the path of a powerful radioactive emmision, such that on the opposite side of the cube is placed a fluorescent screen. It is observed that the shadow formed by aluminium metal is lighter than the lead metal. State one reason for the above phenomenon.
Answer:
The shadow formed by aluminium is lighter as α, β particles are stopped by aluminium and Y -radiations are not stopped by it.
The shadow formed by lead is dark because all the three α, β, Y are stopped by lead.

Question 2.
(a) Explain why a paint, containing of zinc sulphide and a trace of radium salt, glows in the dark.
(b) An isotope of $_{92}U^{238}$ decays into thorium (Th) by the emission to an alpha-particle. The nucleus of thorium then decay into Protactinium (Pa) by the emission of a beta-paticle. Write two nuclear equations to illustrate the above changes.
Ans.
(a) It makes a flourescent material and contains radioactive material like radium.
(b)

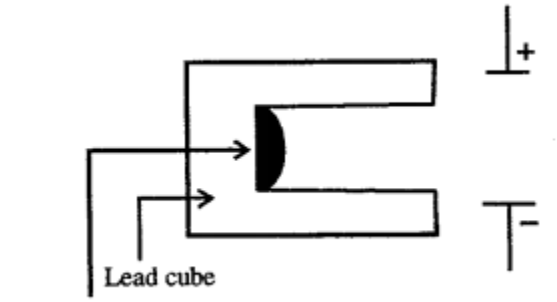
$$_{92}U^{238} \xrightarrow{-\alpha} {}_{90}Th^{234} + {}^{4}_{2}He$$

$$_{90}Th^{234} \xrightarrow{-\beta} {}_{91}Pa^{234} + {}^{0}_{-1}e$$

2004

Question 3.

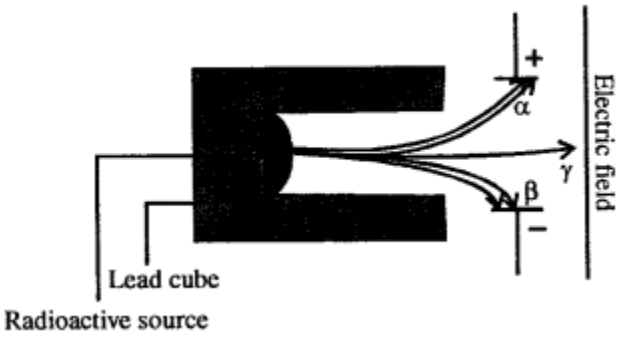
(a) The diagram below shows a thick lead cube having a cavity in the middle. In the cavity is placed some radioactive substance. Copy the diagram and trace the paths of α particles,β particles and Y radiations as they pass through powerful electric field.



(b) Name the radiations which have the least penetrating power.

Answer:

(a)



(b) The alpha radiations being heaviest have the least penetrating power.

Question 4.

Copy and complete the following nuclear equations by filling in the correct values in the blanks

Answer:

$$_{92}X^{238} \xrightarrow{-\alpha} {}_{\cdots\cdots}X_1^{\cdots\cdots} \xrightarrow{-\beta} {}_{\cdots\cdots}X_2^{\cdots\cdots} \xrightarrow{-\beta} {}_{\cdots\cdots}X_3^{\cdots\cdots}$$

$$_{92}X^{238} \xrightarrow{-\alpha} {}_{90}X_1^{234} \xrightarrow{-\beta} {}_{91}X_2^{234} \xrightarrow{-\beta} {}_{92}X_3^{234}$$

2005

Question 5(a).

How many alpha and beta particles are emitted when $^{235}_{92}U$ Uranium nucleus decays to Lead $^{206}_{82}$ Pb ?

Answer:
When $^{235}_{92}U$ decays to $^{235}_{92}U$, the mass number decreases from 238 to 206 i.e. it decreases by 32. Since emission of beta particle (β) does not change the mass number and with the emission of one a (alpha) particle, mass number decreases 4, so total number
of alpha particles emitted will be 32/4 = 8.
In the decay of $^{235}_{92}U$ to lead $^{206}_{82}$ Pb,the atomic number has decreased by 10. But due to emission of 8 α-particles, the atomic mass would have decreased by 2 x 8 = 16. Thus there is an increase in atomic number by 6, hence 6 Beta (β) particles will be emitted. (Because in emission of one beta particle, atomic number increases by 1).
Thus $^{235}_{92}U$ decays to $^{235}_{92}U$ with emission of 8- α particles and 6 β-particles.

Question 5(b).
Mention two important precautions that should be taken while handling radioactive materials.
Answer:

1. Storage of radio active source should be done with great care; they should be enclosed by lead blocks and further surrounded by concrete walls.
2. Artificial, long mechanical 'arms' should be used to handle the more dangerous sources.

Question 5(c).
State one use of radioisotopes.
Answer:
They are used to study the function of fertilizers for different plants. They have also been used for developing new species of a plant by causing genetic mutations. They are also used in treatment of cancer

2006

Question 6.
A certain radioactive nucleus emits a particle that leaves its mass unchanged but increases its atomic number by 1. Identify the the particle and write its symbols.
Answer:
Particle is β(beta) i.e. electron $^{0}_{-1}e$

Question 7.
State three properties that are common to and shown by beta rays and cathode rays.
Answer:

1. Particle of both are electrons and are NEGATIVELY CHARGED.
2. Both are deflected by electric and magnetic field.

3. Both cause FLUORESCENCE.
4. Both produce X-RAYS when stopped by metal of high ATOMIC NUMBER and high melting point (m.p.) such as, TUNGSTEN.

2007

Question 8.

What will an alpha particle change into when it absorbs:

(a) One electron ?

(b) Two electrons?

Answer:

(a) On absorbing one electron, an a — particle ($_2He^4$ nucleus) will change into an helium ¡on which is singly ionised.

(b) On absorbing two electrons, it will change into an helium atom.

Question 9.

(a) What happens to the atomic number of an element when it emits:

1. an alpha particle
2. a beta particle.

(b) Explain why alpha and beta particles are deflected in an electric or a magnetic field but gamma rays are not deflected in such a field.

Answer:

(a)

1. When an a-particle is emitted, its atomic number decreases by 2.
2. When a beat particle is emitted, the atomic number increases by 1.

(b)

α-particles and beta particles when subjected to an electric field are deflected. This is so because both the α -particles and beta particles are charged. Electric field exerts a force on them which deflects them.

However, γ rays are not deflected because they are not charged and do not experience any force. Hence they are not deflected.

2008

Question 10.

(a) What is radioactivity ?

(b) Mention any two differences between nuclear energy and chemcial energy.

Answer:

(a) Radioactivity is a self spontaneous disintegration of a heavy nucleus into α, β, and γ radiations.

(b) Two differences between nuclear energy and chemical energy are as below:

Nuclear energy

1. 1. Nuclear energy is liberated from the nucleus of the atom in which protons and neutrons take part.
2. 2. Nuclear energy produced is tremendous as 1 kg mass gets converted into 9 x 10^{16} J of energy.

Chemical energy

1. Chemical energy is liberated because of electrons which combine or release.
2. A very small amount of energy is released in chemical reactions. It can be absorbed or released.

Question 11(a).
(1) When does the nucleus of an atom become radio active
(2) How is the radioactivity of an element affected when it undergoes a chemical change to form a chemical compound ?
(3) Name the product of nuclear fission which is utilized to bring about further fission of $^{235}_{92}U$
Answer:

1. Nucleus of an atom become radioactive if
   - n/p ratio is more than 1.5 i.e., number of neutrons are much more than number of protons in the nucleus
   - Electrostatic force is "more than nuclear force.
2. No change (:. Any physical or chemical change do not alter the rate of disintegration of radioactive substance).
3. Slow moving neutron.

Question 11(b).
(1) Mention one use and one harmful effect of radioactivity.
(2) Give one source of background radiation.
Answer:

1. **Use :** Radiations from cobalt – 60 are used to treat cancer.
   Harmful Effect : The persons who are exposed to radiations these harmful radiations can kill the living tissues and cause damage.
2. Cosmic rays from high altitudes and internal radiations given out by radioactive element present in the earth's crust.

2009
Question 12(a).
Give two important precautions that should be taken while handling radioactive materials.
Answer:
Two precautions to be taken while handling radioactive substance :

1. Nuclear must be kept in thick lead container with narrow mouth and handled with mechanical tongs, wearing lead lined glasses.
2. The workers must wear special film badges which can absorb nuclear radiation and should under go compulsory medical check up from time to time.

Question 12(b).

(1) What is the name given to atoms of a substance which have the same atomic number but different mass numbers ?

(2) What is the difference in the atomic structures of such atoms ?

Answer:

(1) Isotopes.

(2) Difference in the number of neutrons only.

Example : ${}_{1}^{1}H \Rightarrow {}^{n=0}_{p=0}$

${}_{1}^{2}H \Rightarrow {}^{n=1}_{p=1}$

${}_{1}^{3}H \Rightarrow {}^{n=2}_{p=1}$

Question 13.

A nucleus ${}^{A}_{Z}X$ emits an alpha particle followed.by Yemission; thereafter it emits two β particles to form X_3.

(a) Copy and complete the values of A and Z for X_3 :

$${}^{A}_{Z}X \xrightarrow{-\alpha} X_1 \xrightarrow{-\gamma} X_2 \xrightarrow{-2\beta} .....X_3$$

(b)

- Out of alpha (α), beta (β) and gamma (Y) radiations –
- Which radiation is the most penetrating ?
- Which radiations are negatively charged ?

Answer:

(a) ${}^{A}_{Z}X \xrightarrow{-\alpha} {}^{A-4}_{Z-2}X_1 \xrightarrow{-\gamma} {}^{A-4}_{Z-2}X_2 \xrightarrow{-2\beta} {}^{A-4}_{Z}X_3$

∴ X_3 has mass no A^{-4}

Atomic no. Z i.e, it is an isotope of X

(b)

1. Most penetrating radiation isY.
2. β radiations are negatively charged.

2010

Question 14.
(1) Name the radioactive radiations which have the least penetrating power.
(2) Give one use of radioisotopes.
(3) What is meant by background radiation ?
Answer:

1. α rays have the least penetrating power.
2. Radioisotopes are used to study the function of fertilizer for different plants. They have also been used for developing new species of a plant by causing genetic changes.
3. Background radiations are present at all places even in the absence of any radioactive source. The radiations are present in the atmosphere even when there is no source nearby.
   The source of background radiations are :
   (a) cosmic radiation
   (b) rocks in the earth which contain traces of radioactive substances
   (c) naturally occurring radioisotopes.

Question 15(a).
Complete the following nuclear changes :

$$^{24}_{11}Na \rightarrow \ldots\ldots Mg + {}^{0}_{-1}e$$

Answer:

1. The completed nuclear changes are as below (use the fact that total mass number and charge numbers are always conserved in a nuclear change.

   $$^{238}_{92}U \rightarrow {}^{234}_{90}Th + \ldots\ldots + Energy.$$

   $$^{24}_{11}\mathrm{Na} \rightarrow {}^{24}_{12}\mathrm{Mg} + {}^{0}_{-1}\mathrm{e}$$

   $$^{238}_{92}\mathrm{U} \rightarrow {}^{234}_{90}\mathrm{Th} + {}^{4}_{2}\mathrm{He} + \mathrm{Energy.}$$

2. $^{4}_{2}\mathrm{He}$ is called the α particle.

Question 15(b).
(1) Which radiation produce maximum biological damage?
(2)What happens to the atomic number of an element when the radiation named by you in part
(i) above, are emitted.
Answer:

1. α-radiation being heaviest and slowest causes most biological damage.

2. When a-radiation is emitted, the atomic number decreases by 2.

2011

Question 16(a).

Fill in the blank with appropriate words

During the emission of a beta particle, the **Mass** number remains the same.

Question 16(b).

A mixture of radioactive substances gives off three types of radiations.

1. Name the radiation which travels with the speed of light.
2. Name the radiation which has the highest ionizing power.
3. When an alpha particle gains two electrons it becomes neutral and becomes an atom of an element which is a rare gas. Name of this rare gas ?

Answer:

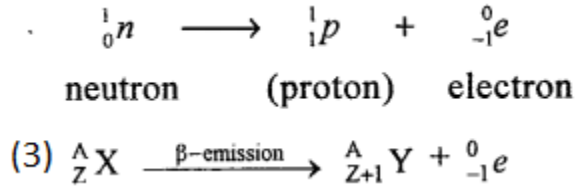
1. γ-rays travels with the speed of light (3 X 10^8 m/s)
2. Alpha particle
3. Rare gas is Helium (He)

Question 16(c).

1. Define radioactivity.
2.What happens inside a nucleus that causes emission of beta particle ?
3. Express the above change in the form of an equation.

Answer:

1. Radioactivity is a phenomenon self spontaneous disintegration of a heavy nucleus in α, β, and γ radiation.
2. During Beta emission, one of the neutrons breaks into an electron and a proton, with the release of energy. The proton remain in the nucleus (atomic number increases by 1), but electron is ejected out.



Question 16(d).

(1) The nucleus $^{202}_{84}X$ emits an alpha particle and forms.The nucleus Y. Represent this

change in the form of an equation.
(2) What changes will take place in the mass number and atomic number of nucleus Y, if it emits gamma radiations ?

Answer:

(1) $^{202}_{84}X \xrightarrow{\alpha\text{-emission}} {}^{198}_{82}Y + {}^{4}_{2}He$

(2) There will be no change

2012

Question 17(a).

(1) What is the value of the speed of gamma radiations in air or vacuum ?
(2) Name any two important sources of background radiation.

Answer:

1. The speed of gamma rays (Y) in air and vaccum is 3×10^8 ms^{-1}.
2. **(a)** The radioactive emissions given out by the earth.
   (b) Sources are K-40, C-14 and Radium contained inside our body.

Question 17(b).

A certain nucleus X has a mass number 14 and atomic number 6. The nucleus X changes to $_7Y^{14}$ after the loss of a particle.

1. Name the particle emitted.
2. Represent this change in the form of an equation.
3. A radioactive substance is oxidized. What change would you expect to take place in the nature of its radioactivity? Give a reason for you answer.

Answer:

(1) The particle emitted is beta particle.

(2) $_6Y^{14} - \beta \longrightarrow {}_7Y^{14}$

(3) No change will take place in its rate of activity. It is because oxidation is a chemical change which takes at electron level. It has nothing to do with nucleus of the atom.

2013

Question 18.

(a) Which of the radioactive radiations –

1. can cause severe genetical disorders.
2. are deflected by an electric field ?

(b) A radioactive nucleus undergoes a series of decays according to the sequence

$$X \xrightarrow{\beta} X_1 \xrightarrow{\alpha} X_2 \xrightarrow{\alpha} X_3$$

If the mass number and atomic number of X are 172 and 69 respectively, what is the mass number and atomic number of X ?

(C)

(1) What is meant by Radioactivity ?

(2) What is meant by nuclear waste ?

(3) Suggest one effective way for the safe disposal of nuclear waste.

Answer:

(a)

(1) Gamma radiations

(2) Alpha and beta radiations

(b)

$$^{172}_{69}X_3 \xrightarrow{+\alpha} {}^{176}_{71}X_2 \; ; \; {}^{176}_{71}X_2 \xrightarrow{+\alpha} {}^{180}_{73}X_1 \quad {}^{180}_{73}X_1 \xrightarrow{+\beta} {}^{180}_{72}X$$

Thus, mass number of X is 180 and atomic number 72 ;

(c)

1. The phenomenon due to the nucleus of certain elements decays on its own, giving out harmful radiations, such as a alpha particles, beta particles and gamma radiations is called radioactivity.
2. The residual material left in the nuclear reactors after generating heat energy is called nuclear waste. The nuclear waste is radioactive and very harmful to the environment.
3. The nuclear waste should be stored in stainless steel containers, lined from within with thick sheets of lead, so that no radioactive rays come out of it. The containers should be stored in safe and well guarded place, so that they do not fall in the hands of criminal elements.

2014

Question 19.

A nucleus $_{11}Na^{24}$ emits a beta particle to change into Magnesium (Mg)

1. Write the symbolic equation of the process.
2. What are numbers 24 and 11 called?
3. What is the general name of $^{24}{}_{11}Mg$ with respect to n Na ?

Answer:

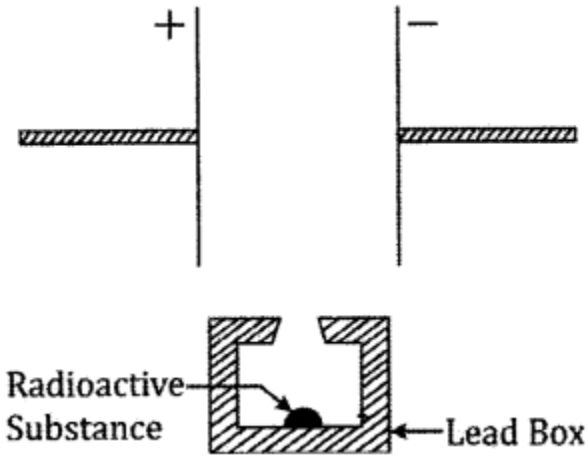
(1) $_{11}NA^{24} \longrightarrow {}_{12}Mg^{24} + {}_{-1}e^{0}$

(2) The number 24 is mass number and 11 is atomic number.

(3) They are isobars.

2015

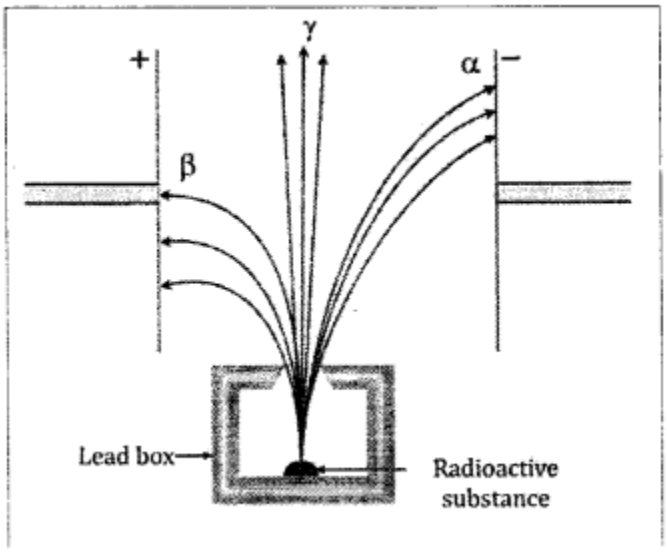
Question 20(a) .



1. Complete the diagram as given below by drawing the deflection of radioactive radiations in an electric filed.
2. State any two precautions to be taken while handling radio – active substances.

Answer:

(1) Deflection of radioactive radiations α, β and Y in an electric field is as shown below:



(2) The two safety precautions to be taken while handling radio active substances are (any two):

1. Radioactive substances should be kept in thick lead containers with a very narrow opening so as to restrict the radiations coming out from other directions.
2. Radioactive materials should be handled with long lead tongs.

3. People working with radioactive substances should put on special lead lined aprons and lead gloves.

Question 20(b).
An atomic nucleus A is composed of 84 protons and 128 neutrons.

1. The nucleus A emits an alpha particle and is transformed into nucleus B. What is the composition of nucleus B?
2. The nucleus B emits a beta particle and is transformed into nucleus C. What is the composition of nucleus C?
3. Does the composition of nucleus C change if it emits gamma radiations?

Answer:

(i) ${}^{(128+84)}_{84}A$ Atomic number 84 = $p = e$

Atomic mass = $p + n$

= 84 + 128 = 212

(i) When α-particle is emitted

Atomic mass decreases by 2 *i.e.* 2 protons are decreased

Mass number decreases by 4 *i.e.* $(2p + 2n)$ are decreased in B

∴ nucleus has 84 – 2 = 82 protons

and 128 – 2 = 126 neutrons

∴ ${}^{(82+126)}_{82}B \longrightarrow {}^{208}_{82}B$

(ii) ${}^{(82+126)=208}_{82}B$ when emits β-particle

Atomic number increases by 1 *i.e.* there are 83 p

Mass number remains the same 1 neutron gets converted into proton

${}_0n^1 \longrightarrow {}^1_1p + {}^0_{-1}e$

∴ Mass number (83p + 125n) = 208

${}^{208}_{82}B \longrightarrow {}^{(83+125)=208}_{(82+1)=83}C + {}^0_{-1}e$

∴ There 83 p and 125 n in the nucleus.

(c) There is no change of nucleus C.

2016

Question 21.

(a) An element $_zS^A$ decays to $_{88}R^{222}$ after emitting 2 alpha particles and 1 beta particle. Find the atomic number and atomic mass of the element S.

(b) A radioactive substance is oxidized. Will there be any change in the nature its radioactivity? Give a reason for your answer.

Answer:

(a) The decay will follow the following sequence

$$_zS^A \xrightarrow{\alpha}{}_{z-2}P^{A-4} \xrightarrow{\alpha}{}_{z-4}Q^{A-8} \xrightarrow{\beta}{}_{z-3}R^{A-8}$$

Therefore, we have

Z – 3 = 85 or Z = 85+ 3 = 88

And A- 8 = 222 or A = 222 + 8 = 230 Z = 88, A = 230

(b) Radioactivity is the nuclear phenomenon, i.e., radioactive radiation are emitted from the nucleus of the radioactive substance, so any physical change like oxidation or any chemical change does not affect its nature of radioactivity.

Question 22.

(a) Arrange α,β, and γ rays in ascending order with respect to their

1. Penetrating power.
2. Ionising power.
3. Biological effect.

(b) (1) Represent the change in the nucleus of a radioactive element when α β particle is emitted.

(2) What is the name given to elements with same mass number and different atomic number.

(3) Under which conditions does the nucleus of an atom tend to radioactive ?

Answer:

(a)

1. Penetrating power : α,β,γ
2. Ionising power : γ, β, α
3. Biological effect = α,β,γ

(b) (1) In an unstable nucleus, the neutron is changed into a proton by emitting a beta particle. This is represented as

$$_zX^A \rightarrow {}_{z+1}X_1^A + {}_{-1}e^0$$

(neutron) (proton) (β-particle)

(2) Elements with the same mass number but different atomic numbers are called isobars.

(3) The nucleus of an atom tends to be radioactive

- When its atomic number exceeds 82.
- There is an imbalance of protons and neutrons as compared to normal stable atom.

Additional Questions

Question 1.
Define nucleons, nuclide, neutrino, antineutrino.
Answer:
NUCLEONS : "The protons and neutrons inside the nucleus are called NUCLEONS."
NUCLIDE : "Representation of an atom along with its ATOMIC NUMBER and MASS NUMBER is called NUCLIDE" e.g. ${}_{Z}X^{A}$ is the nuclide of atom X.
ANTINEUTRINO : "An uncharged particle having negligible small mass emitted along with P-particle is called ANTI NEUTRINO."

1. **ATOMIC NUMBER :** "The number of protons in the nucleus is called ATOMIC NUMBER -Z".
2. **MASS NUMBER :** "The number of protons and neutrons present in nucleus is called MASS NUMBER-A."

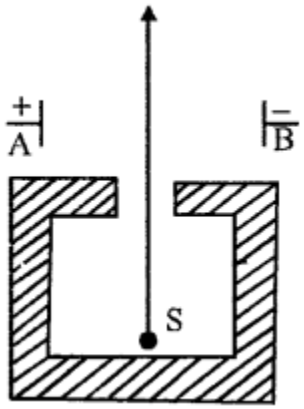
Question 2.
What are isotopes ? Give one example.
Answer:
ISOTOPES : "Atoms of the same element having same ATOMIC NUMBER and different mass number are called ISOTOPES."
Example:
${}_{1}H^{1}$ ${}_{1}H^{2}$, ${}_{1}H^{3}$ Isotopes of Hydrogen
Protium Deuterium Tritium

Question 3.
What are isobars ? Give one example.
Answer:
ISOBARS : "Atoms of different elements having same MASS NUMBER and different ATOMIC NUMBER are called ISOBARS."
Example :
Sodium and Magnesium both have atomic Mass 23 but different Atomic numbers of 11 and 12.
${}_{11}Na^{23}$ ${}_{12}Mg^{23}$

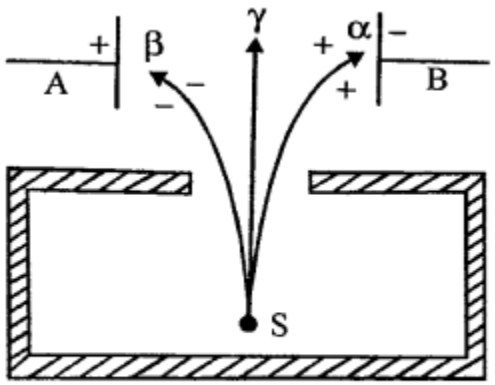
Question 4.
What is radio-activity ? Name two radioactive substances.
Answer:

"The phenomenon of some substances to give out spontaneous emission of invisible radiation which can penetrate through some thickness is called RADIOACTIVITY" and these substances are called RADIOACTIVE SUBSTANCES.
Name of RADIOACTIVE SUBSTANCES : URANIUM, RADIUM, THORIUM, POLONIUM and ACTINIUM.

Question 5.
Fig. shows a radioactive source S in a thick lead container. The radiations pass through an electric field between the plates A and B. Complete the diagram to show the paths of α, β and γ radiations



Answer:



SOME IMPORTANT PROBLEMS

Question 6.
State the penetrating range of α, β and γ radiations.
Answer:
The penetrating range of a-particles is 2.7 cm to 8.62 cm of air, of [β-particles is 5 mm of aluminium or 1 mm of lead and of γ -radiations is about 30 cm of iron.

Question 7.
A radioactive source emits three types of radiations. Name them.

1. Name the radiations which are charged.
2. Name the radiations which are most penetrating.
3. Name the radiations which travel with the speed of light.

Answer:
α, β and γ radiations.

1. α and β radiations are charged.
2. γ (Gamma Radiations) are the most penetrating.
3. γ radiations travel with the velocity of light.

Question 8.
How do infrared and y-rays differ in their :
(1) wavelength
(2) penetrating power ?
Answer:

1. Although both the infrared and y -rays are electromagnetic radiations, y-rays have much shorter wavelength (10^{-13} m) as compared to infrared whose wavelength is nearly 10^{-6} m or more.
2. γ -rays are much more penetrating as compared to the infrared radiations.

Question 9.
State two similarities and two dissimilarities between the y-rays and X-rays.
Answer:
Similarities :

1. Both y -rays and X-rays are the electromagnetic waves.
2. Both travel with speed 3×10^{8} m s^{-1} in air (or vacuum).

Dissimilarities :

1. The wavelength of y -rays is shorter than that of X-rays.
2. y -rays are more penetrating than X-rays.

Question 10.
Is it possible to detect γ radiation in the way that a and β-particles can be deflected using the electric or magnetic field? Give reasons.
Answer:
γ-radiations are electromagnetic waves like light and are not charged particles. Hence can not be deflected by ELECTRIC or MAGNETIC field and cannot be detected.

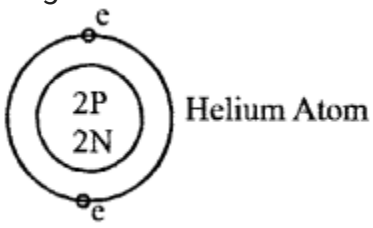
Question 11.
State the penetrating range of α, β and γ radiations.
Answer:
The penetrating range of a-particles is 2.7 cm to 8.62 cm of air, of P-particles is 5 mm of aluminium or 1 mm of lead and . of Y -radiations is about 30 cm of iron.

Question 12.
A mixture of radioactive substance gives off three types of radiations.

1. Name the three types of radiations.
2. Name the type consisting of the same kind of particles as the beam of electrons.
3. One of the radiations is similar to light. Name the radiation.
4. Name the radiations which have the lowest ionising power.
5. Name the radiations which have the lowest penetrating power.
6. Give the charge and mass of particles composing the radiations in (V).
7. Explain why radiations in (V) have the lowest penetrating power.
8. When the particle referred to in (V) becomes neutral, they are found to be the atoms of a rare gas. Name this rare gas and draw a model of its neutral atom.
9. From which part of the atom do these radiations come ?

Answer:

- α, β and γ radiations.
- Beta (β) are fast moving electrons.
- Gamma (γ) radiations travel with the velocity of light.
- Gamma (γ) radiations.
- Alpha (α) radiations.
  Charge on α-particle is POSITIVE and mass 4 times that of proton,
  ∴ α = $_2He^4$
- α-particles have lowest penetrating power because they are massive i.e. mass in more and velocity is least.
- Rare gas is Helium.



Helium Atom

- Model of neutral atom is
- From the nucleus.

Question 13.
A radioactive substance emits radiations :

(a) α, β and γ simultaneously .
(b) in the order α, β and γ one by one
(c) at one time α and β and then γ
(d) α and γ or β and γ

Question 14.
A radioactive sample is kept at the center of a large evacuated sphere. How safe will it be ?
Answer:
For safety, the radiations {α, β and γ emitted by the radioactive sample should not come out of the sphere, α-particles have a less penetrating power and therefore, the walls of the sphere easily stop them. β-particles will not he stopped by the walls and there will be no absorption of β particles inside the sphere as the air has been withdrawn from it. The number of β particles reaching per unit area at the surface of sphere will depend on the radius of sphere. This number will be reduced to 1/4, if the radius is doubled. So some safety is obtained if the sphere is large.
γ-radiations are also not absorbed by the walls.Thus for safety, the container should have lead walls and it should not be evacuated. The air will help in absorbing the radiations.Thus for safety, the container should have lead walls and it should not be evacuated. The air will help in absorbing the radiations.

Question 15.
Which of the radiations α, β and γ is similar to a beam of electrons?
Answer:
β-RADIATION is similar to a beam of electrons.

Question 16.
Give the relative ionising power of α, β and γ radiations.
Answer:
α-particles being the heaviest have maximum ionisation power. It is about 10^2 times that of β-particles and 10000 times that of gamma (γ) radiation.

Question 17.
A mass of lead is embedded in a block of wood. Radiations from a radioactive source incident on the side of block produce a shadow on a fluorescent screen placed beyond the block. The shadow of wood is faint but the shadow of lead is dark. Give reason for this difference.
Answer:
The shadow of wood is faint because only the α-radiations are stopped by wood (since α-radiations are least penetrating). The shadow of lead is dark because β and γ - radiations are also stopped by lead. (If wood is replaced by aluminium or any other light metal, the appearance on screen and reason will be the same), i.e. shadow will be dark.

Question 18.
What is meant by nuclear energy ?
Answer:
NUCLEAR ENERGY : "Energy obtained from the nucleus of atom i.e. from defect mass is called NUCLEAR ENERGY."

Question 19.
What is Einstein's mass-energy relation ?
Answer:
$E = mc^2$ is Einstein's mass-energy relation.

Question 20.
Calculate the energy released when a mass of 1 kg is completely converted into energy.
Answer:
According to Einstein's mass-energy equivalence
$E = mc^2$
$E = 1 \text{ kg} \times [3 \times 10^8 \text{ ms}^{-1}]^2$
Energy released $E = 1 \times 3 \times 10^8 \times 3 \times 10^8 = 9 \times 10^{16}$ J

Question 21.
State the unit in which the mass of nuclear particles is expressed. How is it related to kg ?[V.Imp.] **Answer:**
Mass of nuclear particles is expressed in
u → Unified atomic mass unit
$1 \text{ u} = 1.6603 \times 10^{-27}$ kg = 931 MeV in terms of energy

Question 22.
Calculate the energy released in the following fission reaction:

reaction:

$$^{935}_{92}\text{U} + ^{1}_{0}\text{n} \longrightarrow ^{141}_{56}\text{Ba} + ^{92}_{36}\text{Kr} + 3\,^{1}_{0}\text{n} \qquad \textit{[V.Imp.]}$$

Given : $^{935}_{92}\text{U} = 235.0439\ u.,\ ^{1}_{0}n = 1.0087\ u.$

$^{141}_{56}\text{Ba} = 140.9139\ u.,\ ^{92}_{36}\text{Kr} = 91.8973\ u$

Answer:

Mass defect in the given fission reaction

$$\Delta m = ({}^{235}_{92}\mathrm{U}) + m({}^{1}_{0}n) - m({}^{141}_{56}\mathrm{Ba}) - m({}^{92}_{36}\mathrm{Kr}) - 3 \times m({}^{1}_{0}n)$$

$$= [235.0439 + 1.0087 - 140.9139 - 91.8973 - 3 \times 1.0087]\ u.$$

$$= 0.2153\ u.$$

Since $1u = 931$ MeV.

Hence energy released in the fission reaction

$$E = 0.2153 \times 931 \text{ MeV} = 200.44\ MeV$$

Question 23.

Uranium nucleus $^{235}_{92}U$ decays to lead nucleus $^{206}_{82}$ Pb .How many alpha and beta particles are emitted ?

Answer:

When $^{235}_{92}U$ decays to $^{206}_{82}$ Pb, the mass number decreases from 238 to 206 i.e., it decreases by 32. Since with the emission of one alpha particle, mass number decreases by 4, so total number of alpha particles emitted will be 32/4 = 8

In decay of $^{235}_{92}U$ to $^{206}_{82}$ Pb, the atomic number has decreased by 10. But due to emission of 8 alpha particles, the atomic number would have decreased by 2 x 8 = 16. Thus there is an increase in atomic number by 6, hence 6 beta particles will be emitted (because in emission of one beta particle, atomic number increases by 1). Thus $^{235}_{92}U$ decays to $^{206}_{82}$ Pb with the emission of 8 a-particles and 6 P-particles.

Question 24.

If the loss in mass in fission of a uranium nucleus is 205 u, find the energy released. Take lu = 931 MeV.

Answer:

Energy released = 0.205 x 931 MeV
= 190.86 MeV

Question 25.

What is nuclear fission ?

Answer:

NUCLEAR FISSION : "The process in which an unstable nucleus of a heavy atom (like uranium -235) by bombardment with slow neutrons, splits up into two daughter medium weight nuclei with liberation of an enormous amount of energy is called NUCLEAR

FISSION."

$$_{92}U^{235} + {}_{0}n^{1} \xrightarrow{\text{fission}} {}_{56}Ba^{139} + {}_{36}Kr^{94} + 3\ {}_{0}n^{1} + \text{large amount of energy.}$$

Question 26.

What is nuclear fusion ?

Answer:

NUCLEAR FUSION : "When two light nuclei combine to form a heavier nucleus, the process is called nuclear fusion."

$$_{1}^{2}H + {}_{1}^{3}H \xrightarrow{\text{fusion}} {}_{2}^{4}He + {}_{0}^{1}n + \text{energy (very large)}$$

$$_{1}^{2}H + {}_{1}^{2}H \xrightarrow[4 \times 10^{6}\,^{\circ}C]{\text{fusion}} {}_{2}^{3}He + {}_{0}^{1}n + \text{enormous energy}$$