EXERCISE 12(B)

Solution:
The energy released by the nucleus of an atom during nuclear reaction i.e., during fission or fusion is called as nuclear energy. Nuclear fission and nuclear fusion are responsible for the release of nuclear energy.

Solution:
Einstein's mass-energy equivalence relation is $E = (\Delta m)\, c^2$
Here Δm is the loss in mass in kg, c is the speed of light ($= 3 \times 10^8$ m s^{-1}) and E is the energy in joule (J).

(a) Solution:
The mass of atomic particles expressed in atomic mass unit (a.m.u) where 1 a.m.u. = 931

MeV.
The mass of a proton = 1.00727 a.m.u.
The mass neutron = 1.00865 a.m.u.
The mass of electron = 0.00055 a.m.u.

Solution:
Nuclear fission is the process in which a heavy nucleus splits into two lighter nuclei of nearly the same size, when bombarded with slow neutrons.

$$^{235}_{92}U + ^{1}_{0}n \longrightarrow (^{236}_{92}U) \longrightarrow ^{144}_{56}Ba + ^{89}_{36}Kr + 3\ ^{1}_{0}n + \text{energy}$$

Solution:
(a) $^{238}_{92}U$ and $^{235}_{92}U$ are the isotopes which are fissionable
(b) $^{235}_{92}U$ is more easily fissionable than the isotope $^{238}_{92}U$. This is because the fission of $^{238}_{92}U$ nucleus is possible only by the fast neutrons, while the fission of $^{235}_{92}U$ nucleus can be even by the slow neutrons.
(c) Both slow and fast

Question: 6
Write the approximate value of the energy released in the fission of one nucleus of $^{235}_{92}U$. What is the reason for it?
Solution:
In the fission of one $^{235}_{92}U$ nucleus, nearly 190 MeV energy is released. The loss in mass is the main cause of emission of this energy i.e., the sum of masses of product nuclei is less than the sum of mass of the parent nucleus and the mass of neutron.

Question: 7
Complete the following nuclear fission reactions:

(a) $^{235}_{92}\text{U} + {}^{1}_{0}\text{n} \longrightarrow {}_{56}\text{Ba} + {}^{92}\text{Kr} + 3\,{}^{1}_{0}\text{n} + \ldots\ldots$

(b) $^{235}_{92}\text{U} + {}^{1}_{0}\text{n} \longrightarrow {}^{148}\text{La} + {}^{85}_{35}\text{Br} + \ldots\ldots\,{}^{1}_{0}\text{n}$ **+ energy**

Solution:

(a) $^{235}_{92}\text{U} + {}^{1}_{0}\text{n} \longrightarrow {}^{141}_{56}\text{Ba} + {}^{92}_{36}\text{Kr} + 3\,{}^{1}_{0}\text{n}$ + energy

(b) $^{235}_{92}\text{U} + {}^{1}_{0}\text{n} \longrightarrow {}^{148}_{57}\text{La} + {}^{85}_{35}\text{Br} + 3\,{}^{1}_{0}\text{n}$ + energy

Question: 8
What do you mean by the chain reaction in nuclear fission? How is it controlled?
Solution:
A process in which a neutrons released in fission produces an additional fission in at least one further nucleus releasing enormous amount of energy is known as a chain reaction. The chain reaction is controlled by absorbing some of the neutrons emitted in the fission process by means of the cadmium rods and then making them slow by the moderators such as graphite, heavy water, etc, the energy obtained in fission can be utilized for the constructive purposes.

Question: 9
State two uses of nuclear fission?
Solution:
Nuclear fission can be used in two ways
(i) It is used in a nuclear bomb where the energy released is fast and uncontrolled
(ii) It is used in a nuclear reactor where the rate of release of energy is slow and controlled. This energy is used to generate the electric power.

Question: 10
Give two differences between the radioactive decay and nuclear fission.
Solution:

Radioactive decay	Nuclear fission
It is a spontaneous process	It does not occur by itself. It is initiated when, neutrons are bombarded on a heavy nucleus
The rate of radioactive decay cannot be controlled	The rate of nuclear fission can be controlled

Question: 11
(a) What is nuclear fusion? Give one example and write its nuclear reaction.

(b) What other name is given to nuclear fusion? Give reason.
Solution:
A nuclear fusion is the process in which two light nuclei combine to form a heavy nucleus releasing huge amount of energy.
Example: Hydrogen and hydrogen can fuse to form helium

$$ {}^{2}_{1}H + {}^{3}_{1}H \longrightarrow {}^{4}_{2}He + {}^{1}_{0}n + 17.6\text{ MeV} $$

(b) Nuclear fusion is also called as thermo-nuclear reaction because nuclear fusion takes place at very high temperature

Question: 12
Why is a very high temperature required for the process of nuclear fusion? State the approximate temperature required.
Solution:
When two nuclei approach each other, due to their positive charge, the electrostatic force of repulsion becomes too strong between them that they donot fuse. Hence, at ordinary temperature and pressure nuclear fusion is not possible.
To make the fusion possible, a high temperature of approximately 10^7 K and high pressure is required. Due to thermal agitations both nuclei acquire sufficient kinetic energy at such a high temperature so as to overcome the force of repulsion between them when they approach each other and so they get fused.

Question: 13
(a) Write one nuclear fusion reaction.
(b) State the approximate value of energy released in the reaction mentioned in part (a).
(c) Give reason for the release of energy stated in part (b).
Solution:
(a)

$$ \underset{\text{(deuterium)}}{{}^{2}_{1}H} + \underset{\text{(deuterium)}}{{}^{2}_{1}H} \longrightarrow \underset{\text{(helium isotope)}}{{}^{3}_{2}He} + \underset{\text{(neutron)}}{{}^{1}_{0}n} + 3.3\text{ MeV} $$

(b)

$$ \underset{\text{(helium isotope)}}{{}^{3}_{2}He} + \underset{\text{(deuterium)}}{{}^{2}_{1}H} \longrightarrow \underset{\text{(helium)}}{{}^{4}_{2}He} + \underset{\text{(proton)}}{{}^{1}_{1}H} + 18.3\text{ MeV} $$

Thus in all three deuterium nuclei fuse to form a helium nucleus with a release of 21.6 MeV.

When two deuterium nuclei $({}^{2}_{1}H)$ fuse, 3.3 MeV energy is released and the nucleus of helium isotope $({}^{3}_{2}He)$ is formed. In this process again this helium isotope gets fused with one deuterium nucleus to form a helium nucleus $({}^{4}_{2}He)$ and 18.3 MeV is released.

Question: 14

Complete the following fusion reactions:

(a) ${}^{3}_{2}He + {}^{2}_{1}H \longrightarrow {}_{2}He + {}_{1}H$ **+ energy**

(b) ${}^{2}_{1}H + {}^{2}_{1}H \longrightarrow {}_{2}He + {}^{1}n$ **+ energy**

Solution:

Following are the complete fusion reactions

(a) ${}^{3}_{2}He + {}^{2}_{1}H \longrightarrow {}^{4}_{2}He + {}^{1}_{1}H$ + energy

(b) ${}^{2}_{1}H + {}^{2}_{1}H \longrightarrow {}^{3}_{2}He + {}^{1}_{0}n$ + energy

Question: 15

(a) Name the process, nuclear fission or nuclear fusion, in which the energy released per unit mass is more?

(b) Name the process, fission or fusion which is possible at ordinary temperature.

Solution:

(a) The process in which the energy released per unit mass is more is nuclear fusion

(b) The process which is possible at ordinary temperature is nuclear fission

Question: 16

(a) State one similiarity in the process of nuclear fission and fusion.

(b) State two differences between the process of nuclear fission and fusion.

Solution:

(a) Similiarity: Both nuclear fission and fusion release large amounts of energy

(b) (i) In nuclear fission when neutrons are bombarded on a heavy nucleus, it splits in two nearly equal light fragments whereas in nuclear fusion, at a very high temperature and high pressure two light nuclei combine to form a heavy nucleus

(ii) Nuclear fission is possible at ordinary temperature and ordinary pressure whereas nuclear fusion is possible only at a very high temperature and a very pressure.

Question: 17

Give two examples of nuclear fusion.

Solution:

(i)

$$^{1}_{1}H \text{ (proton)} + ^{1}_{1}H \text{ (proton)} \longrightarrow ^{2}_{1}H \text{ (deuterium)} + 0.42 \text{ MeV}$$

(ii)

$$^{2}_{1}H \text{ (deuterium)} + ^{2}_{1}H \text{ (deuterium)} \longrightarrow ^{3}_{1}H \text{ (tritium)} + ^{1}_{1}H \text{ (proton)} + 4.0 \text{ MeV}$$

Question: 18

What is the source of energy of sun or stars?

Solution:

The source of energy of the sun or stars is the nuclear fusion of light nuclei such as hydrogen present in their inner part at a very high temperature and a high pressure. This results the formation of helium nucleus with a release of tremendous amount of energy.

Question: 19

Name the following nuclear reactions:

(a)

$$^{235}_{92}U + ^{1}_{0}n \longrightarrow ^{90}_{38}Sr + ^{143}_{54}Xe + 3\ ^{1}_{0}n + \gamma$$

(b)

$$^{3}_{1}H + ^{2}_{1}H \longrightarrow ^{4}_{2}He + ^{1}_{0}n + \gamma$$

Solution:

(a) The name of the reaction is nuclear fission

(b) The name of the reaction is nuclear fusion

MULTIPLE CHOICE TYPE

Question: 1

The particle used in nuclear fission for bombardment is:

(a) alpha particle

(b) proton

(c) beta particle

(d) neutron.

Solution:

The particle used in nuclear fission for bombardment is neutron

Question: 2

The temperature required for the process of nuclear fusion is nearly:

(a) 1000 K

(b) 10^4 K
(c) 10^5 K
(d) 10^7 K
Solution:
The temperature required for the process of nuclear fusion is nearly 10^7 K

NUMERICALS
Question: 1
In fission of one uranium-235 nucleus, the loss in mass is 0.2 a.m.u. Calculate the energy released.
Solution:
We know that,
1 a.m.u = 931 MeV
During nuclear fission the reaction mass defect is converted into energy release = 0.2 a.m.u
Hence, E = 0.2 × 931
E = 186.2 MeV
Question: 2
When four hydrogen nuclei combine to form a helium nucleus in the interior of sun, the loss in mass is 0.0265 a.m.u. How much energy is released?
Solution:
Given
Δm = 0.0265 a.m.u.
1 a.m.u = 931.5 MeV of energy
Therefore energy liberated equivalent to 0.0265 a.m.u. is
= 0.0265 a.m.u. × 931.5 MeV
= 24.7 MeV