1. Define atom. *(ALP)*
The smallest part of an element is called an atom. The word atom is derived from the Greek word "atomos", meaning "indivisible."

2. Define nucleus. *(ALP)*
Rutherford discovered that the positive charge in an atom was concentrated in a small region called nucleus. The nucleus contains protons and neutrons which are collectively called **nucleons**.

3. Define atomic number. *(ALP)*
The atomic number Z is equal to the number of protons in the nucleus.

4. Define neutron number. *(ALP)*
The neutron number N is equal to the number of neutrons in the nucleus.

***5. Define atomic mass number. Also write its formula.** *(ALP)*
The atomic mass number A is equal to the number of nucleons (protons + neutrons) in the nucleus i.e.,

$$A = Z + N$$

***6. What is meant by Nuclide?** *(ALP)*
If atomic number of an atom is Z and its atomic mass number is A then this atom is represented by the symbol ${}^A_ZX$ which is called nuclide.

For example, nuclide of hydrogen atom having only one proton is ${}^1_1H$.

****7. Define isotope. Give example.** *(ALP)*
Isotopes are atoms of an element which have same number of protons but different number of neutrons in their nuclei.

For example, Hydrogen has three isotopes. These are Protium ${}^1_1H$, Deuterium ${}^2_1H$ and Tritium ${}^3_1H$.

****8. Define natural radioactivity and artificial radioactivity.** *(ALP)*
Natural Radioactivity: The spontaneous emission of radiation by unstable nuclei is called natural radioactivity.

Artificial Radioactivity: The process in which stable nuclide can be changed into unstable nuclide by bombardment of particles like neutrons is called artificial radioactivity.

9. Define radioactive elements. *(ALP)*
The elements which emit radiations naturally are called radioactive elements.

The elements whose atomic number is greater than 82 are naturally unstable.

10. Write the names of the types of radiations. *(ALP)*
Three types of radiation are usually emitted by a radioactive substance. They are:

(i) alpha (α) particles
(ii) beta (β) particles
(iii) gamma (γ) rays

****11. What is meant by background radiations?** *(ALP)*
Radiations present in atmosphere due to different radioactive substances are called background radiations.
Sources: Everywhere in rocks, soil, water and air of our planet (Earth) there are traces of radioactive elements. They emit the radiation every time; this natural radioactivity is called the background radiation.

****12. What is meant by cosmic radiations?** *(ALP)*
The Earth, and all living things on it also receive radiation from outer space. This radiation is called cosmic radiation which primarily consists of protons, electrons, alpha particles and larger nuclei.

****13. Define transmutation.** *(ALP)*
The spontaneous process in which a parent unstable nuclide changes into a more stable daughter nuclide with the emission of radiations is called nuclear transmutation.

***14. Write general equations and examples of $\alpha-decay$.** *(ALP)*
General Equation:

$$\underset{parent\ nuclide}{{}^A_ZX} \longrightarrow \underset{daughter\ nuclide}{{}^{A-4}_{Z-2}Y} + \underset{\alpha-particle}{{}^4_2He} + Energy$$

It means in alpha decay, the proton number or atomic number Z of the parent nuclide reduces by 2 and its mass number or nucleon number A decreases by 4.
Example:

$$\underset{radium}{{}^{226}_{88}Ra} \longrightarrow \underset{radon}{{}^{222}_{86}Rn} + \underset{\alpha-particle}{{}^4_2He} + Energy$$

***15. Write general equations and examples of $\beta-decay$.** *(ALP)*
General Equation:

$$\underset{parent\ nuclide}{{}^A_ZX} \longrightarrow \underset{daughter\ nuclide}{{}_{Z+1}^{A}Y} + \underset{\beta-particle}{{}^0_{-1}e} + Energy$$

In beta (β)-decay , the parent nuclide has its proton number Z increased by 1 but its mass number or nucleon number A remains unchanged.
Example:

$$\underset{carbon}{{}^{14}_6C} \longrightarrow \underset{nitrogen}{{}^{14}_7N} + \underset{\beta-particle}{{}^0_{-1}e} + Energy$$

***16. Write general equations and examples of $\gamma-decay$.**
General Equation:

$$^{A}_{Z}X^{*} \longrightarrow {}^{A}_{Z}Y + \gamma$$
$$parent\ nuclide \quad daughter\ nuclide \quad \gamma - particle$$

Gamma rays are usually emitted along with either an alpha or a beta particle.

Example:

$$^{60}_{27}Co^{*} \longrightarrow {}^{60}_{27}Co + {}^{0}_{0}\gamma + Energy$$
$$cobalt \quad cobalt \quad \gamma - rays$$

17. Write properties of alpha radiations.** ***(ALP)

(i) Alpha particle is a helium nucleus comprising of two protons and two neutrons with a charge of 2e.

(ii) An unstable nucleus with large protons and neutrons may decay by emitting alpha radiations.

18. Write properties of beta radiations.** ***(ALP)

(i) Beta radiation is a stream of high-energy electrons.

(ii) Unstable nuclei with excess of neutrons may eject beta radiations.

19. Write properties of gamma radiations.** ***(ALP)

(i) Gamma radiations are fast moving light photons.

(ii) They are electromagnetic radiations of very high frequency (short wavelength) emitted by the unstable excited nuclei.

20. Write SI unit of radioactivity. ***(ALP)***

The SI unit for radioactivity is the Becquerel, (Bq). In SI base units,

$$1\ Bq = 1\ disintegration\ per\ second\ (dps)$$

This is a very small unit. For example, $1.0\ g$ of radium has an activity of $3.73 \times 10^{10}\ Bq$.

****21. What is meant by ionizing effect of radiation (ionization)?** ***(ALP)***

The phenomenon by which radiations split matter into positive and negative ions is called ionization.

****22. Define penetrating ability.** ***(ALP)***

The strength of radiations to penetrate a certain material is called penetrating power.

****23. Define Half-Life. Also write half-life of $^{14}_{6}C$ and radium-226.** ***(ALP)***

The time during which half of the unstable radioactive nuclei disintegrate is called the half-life of the sample of radioactive element.

Half-life of carbon-14 is 5730 $years$ and radium-226 has a half-life of 1620 $years$.

****24. What is difference between stable and unstable nuclei?** ***(ALP)***

Stable Nuclei	Unstable Nuclei
Nuclei which do not emit radiations naturally are called stable nuclei.	Nuclei which emit different type of radiations naturally are called unstable nuclei.
Most of the nuclei with atomic number **1** to **82** are stable nuclei.	The elements whose atomic number is greater than 82 are naturally unstable.

****25. Define radioisotopes.** ***(ALP)***

The stable and non-radioactive elements can also be changed into radioactive elements by bombarding them with protons, neutrons or alpha particles. Such artificially produced radioactive elements are called radioactive isotopes or radioisotopes.

Here are some examples of the production of radioisotopes:

1. $^{1}_{0}n + {}^{23}_{11}Na \longrightarrow {}^{24}_{11}Na +$ gamma (γ)-rays
   neutron, stable sodium nuclide, a sodium radioisotope

2. $^{4}_{2}He + {}^{27}_{13}Al \longrightarrow {}^{30}_{15}P + {}^{1}_{0}n$
   alpha particle, stable aluminium nuclide, a phosphorous radioisotope

26. Write down uses of radioisotopes.** ***(ALP)

Radioisotopes are frequently used in medicine, industry and agriculture for variety of useful purposes. Following are few applications of radioisotopes in different fields.

(i) Tracers **(ii)** Medical Treatment **(iii)** Carbon Dating

27. What is meant by tracers.** ***(ALP)

Radioactive tracers are chemical compounds containing some quantity of radioisotope.

They can be used to explore the metabolism of chemical reactions inside the human body, animals or plants.

****28. Describe two uses of radioisotopes in medicine, industry or research.** ***(ALP)***

In medicine:

(i) Radio Iodine -131 is used in curing cancer of thyroid gland.

(ii) P – 32 is used to diagnose the brain tumors.

In industry:

(i) To locate the wear and tear of the moving parts of machinery.

(ii) For the location of leaks in underground pipes.

In agriculture:

(i) P – 32, to find how well the plants are absorbing fertilizer.

(ii) Radioisotopes were used for producing high yielding crop seeds to increase the agricultural yield.

****29. Write down the use of radioisotopes in medical treatment.** *(ALP)*
Radioisotopes are also used in nuclear medicines for curing various diseases. For example, radioactive cobalt-60 is used for curing cancerous tumors and cells. The radiations kill the cells of the malignant tumor in the patient.

30. Write down the use of radioisotopes in carbon dating. *(ALP)*
Radioactive carbon-14 is present in small amount in the atmosphere. Live plants use carbon dioxide and therefore become slightly radioactive. When a tree dies, the radio carbon-14 present inside the plant starts decaying.

Since the half-life of carbon-14 is 5730 years, the age of a dead tree can be calculated by comparing the activity of carbon-14 in the live and dead tree.

****31. Define fission reaction.** *(ALP)*
Nuclear fission takes place when a heavy nucleus, such as U-235, splits, or fissions, into two smaller nuclei by absorbing a slow moving (low-energy) neutron as represented by the equation:

$$^{1}_{0}n + {}^{235}_{92}U \rightarrow {}^{236}_{92}U^{*} \rightarrow X + Y + neutrons$$

Where U^{*}-236 is an intermediate state that lasts only for a fraction of second before splitting into nuclei X and Y, called **fission fragments**.

32. Briefly explain how heat is produced in nuclear reactor? OR Write the equation of fission reaction. *(ALP)*
The fission of U-235 may be represented as

$$^{1}_{0}n + {}^{235}_{92}U \longrightarrow {}^{141}_{56}Ba + {}^{92}_{36}Kr + 3\,{}^{1}_{0}n + Q$$

Where Q is amount of energy released and it is nearly equal to 200 MeV. This energy is appeared in form of heat.

Note: Energy produced through fission is a large amount of energy relative to the amount released in chemical processes. For example, if we burn 1 *tonne* of coal, then about $3.6 \times 10^{10}\ J$ of energy is released. But, during the fission of $1\ kg$ of U-235 about $6.7 \times 10^{11}\ J$ of energy is released.

33. What is meant by electron volt? *(ALP)*
Electron volt is also a unit of energy used in atomic and nearly physics:

$$1\ eV = 1.6 \times 10^{-19}\ J$$

****34. Define nuclear fusion with example.** *(ALP)*
When two light nuclei combine to form a heavier nucleus, the process is called **nuclear fusion**.

For example, if an atom of Deuterium is fused with an atom of Tritium, then a Helium nucleus or alpha particle is formed as given by

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

35. What is difference between nuclear fission and fusion? *(ALP)*

Nuclear Fission	Nuclear Fusion
A bigger heavier nucleus splits into smaller (lighter) nuclei.	Lighter nuclei fuse together to form heavier nucleus.
A chain reaction sets in.	It is not a chain reaction.
It can be controlled and energy released can be used for peaceful purpose.	It cannot be controlled and energy released cannot be used properly.

****36. What are two common radiation hazards? Briefly describe the precautions that are taken against them.**
Radiation hazards:
(i) Radiation burns, mainly due to beta and gamma radiations, which may cause redness and sores on the skin.
(ii) Sterility (i.e., inability to produce children).
(iii) Genetic mutations in both human and plants. Some children are born with serious deformities.
(iv) Leukemia (cancer of the blood cells).
(v) Blindness or formation of cataract in the eye.

Precautions to minimize radiation dangers:
We should strictly follow the given safety precautions, even when the radioactive sources are very weak.
(i) The sources should only be handled with tongs(چمٹی) and forceps.
(ii) The user should use rubber gloves and hands should be washed carefully after the experiment.
(iii) All radioactive sources should be stored in thick lead containers.
(iv) Never point a radioactive source towards a person.
(v) Frequent visits to the radiation sensitive areas should be avoided.

Important Long Questions

(1) Explain the process of natural radioactivity.
(2) What is meant by background radiations? Enlist some sources of background radiation.
(3) Define nuclear transmutation. Also describe alpha and beta decay.
(4) Write general equations with α, β and γ decay with examples.

(5) Define half-life of radioactive element. Explain with example.

(6) What is meant by radio isotope? Describe their uses in medicine industry and agriculture.

(7) State and explain nuclear fission reaction.

(8) Nuclear fusion reaction is more reliable and sustainable source of energy than nuclear fission chain reaction. Justify.

(9) What are two common radiation hazards? Briefly describe the precautions that are taken against them.