Descriptive Questions

Q.1 (Ex. Q.4 (i)) Explain the structure of a hydrogen atom.

Ans. Hydrogen atom is the simplest and most abundant element in the universe. Hydrogen atom consists of just one proton in its nucleus and one electron orbiting around the nucleus. This electron is typically found in the first energy level or shell of the atom that is K-shell.

Structure:

The structure of hydrogen atom can be visualized as a tiny nucleus at the center surrounded by a cloud of probability where the electron can be found. The nucleus of the hydrogen may or may not have neutrons in it. There are three isotopes of hydrogen represented as ^{1}H, ^{2}H, and ^{3}H. All these isotopes have one proton in nucleus and one electron around nucleus but the number of neutrons are different.

- ^{1}H (Protium) has no neutron in it
- ^{2}H (Deuterium) has one neutron in it
- ^{3}H (Tritium) has two neutrons in it

The electron doesn't follow a fixed path like planets around the sun but is more accurately described by a probability distribution indicating the probability of finding an electron at a particular location around the nucleus.

Transition of electrons:

The electron in a hydrogen atom occupies the lowest energy level known as the ground state. When energy is added to the atom, the electron can jump to higher energy level but it tends to return to the ground state by emitting energy in the form of light.

Q.2 (Ex. Q.4 (ii)) How does the theory of atomic structure explain the ionization of atoms by a radioactive isotope?

Ans. When a radioactive isotope undergoes decay, it emits radiation in the form of alpha, beta or gamma particles. These emitted particles can interact with atoms leading to the ionization of atoms.

Theory of atomic structure:

According to this theory, atoms are composed of a nucleus containing protons and neutrons surrounded by electrons in various energy levels or shells.

Ionization of atoms by a radioactive source:

Radiation emitted from a radioactive source causes atoms to ionize. For example, radiation emitted by a radioactive element Radium-226 can remove electrons from the atom. However, this ionizing radiation should have enough energy to remove the tightly bound electron from the orbit of an atom. Electron can be lost because an ionizing radiation collides with the atom and forces the electron to move out of the atom. If an atom of sodium is hit by an ionizing radiation, it may lose an electron. This process converts the atom into a positively charged ion (cation).

$Na + Energy \rightarrow Na^{+} + e^{-}$ (Cation)

However, the electron will be lost only when there is another atom which can accept it.

$Cl + e^{-} \rightarrow Cl^{-} + Energy$

Q.3 (Ex. Q.4 (iii)) What is radioactivity? Explain any three applications of radioactive isotopes. **Taleemzone.com**

Ans. Radioactivity: The isotopes of the same element do not have the same physical properties. Several isotopes of the same elements exist whose nuclei are unstable. They emit excess energy in the form of radiation. This process of emission is called **radioactivity** and the isotope which emits energy is called **radioactive isotope**. Every element has one or more radioactive isotope.

Radioactive Decay:

Tritium (^{3}H) is a radioactive isotope and the other two are stable and do not emit any radiation. When a radioactive element emits radiation, it is transformed into another element. This process is called **radioactive decay**. This new element may be stable or may be radioactive so that it also emits radiation.

Examples:

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

(Uranium) → (Thorium)

Thorium is unstable and further disintegrates to give Pa (Protactinium):

$$^{234}_{90}Th \rightarrow {}^{234}_{91}Pa + Energy$$

(Thorium) → (Protactinium)

$$^{210}_{83}Bi \rightarrow {}^{210}_{81}Tl + Energy$$

(Bismuth) → (Thallium)

Applications of Radioactive Isotopes:

(i) Medical purpose:

Radioactive isotopes are useful in medical imaging. Doctors use them to diagnose disease by injecting the patient with a small amount of radioactive fluid. Technetium-99 is used for diagnostic imaging across human organs like brain, lungs, etc. Doctors use a special camera to watch how the radioactive fluid moves.

(ii) Archaeological purpose:

Radiocarbon dating is a method for finding out the age of a historical object containing organic material with the help of radioactive isotope of carbon (^{14}C). The method involves measuring the proportion of ^{14}C in a sample from a dead plant or animal like a piece of wood or a bone which provides information that can be used to calculate when an animal or plant died. The older the sample is, the less ^{14}C is to be detected.

(iii) Construction and power generation purpose:

Radioactive isotopes are used to test the strength of metals and concrete mixture. They are used to generate cheap nuclear power and to find oil fields.

Q.4 (Ex. Q.4 (iv)) Find out the relative atomic mass of mercury from the following data.

Isotope	Relative Abundance
^{196}Hg	0.0146%
^{198}Hg	10.02%
^{199}Hg	16.34%
^{200}Hg	13.22%
^{201}Hg	23.13%

Isotope	Relative Abundance
^{202}Hg	29.80%
^{204}Hg	6.85%

Ans.
Relative atomic mass of mercury:
= (0.0146×196 + 10.02×198 + 16.34×199 + 13.22×200 + 23.13×201 + 29.80×202 + 6.85×204) / 100
= **199.387** amu

Investigative Questions
Q.1 (Ex Q.5 (i)) How can scientists synthesize elements in the laboratory?
Ans. Scientists can synthesize elements in the laboratory through processes like nuclear fission, nuclear fusion and particle bombardment. These methods involve manipulating atomic nuclei to create new elements that do not exist naturally or are not abundant in nature.
Nuclear Fusion:
In nuclear fusion, scientists combine atomic nuclei into heavier elements. This process is commonly used in nuclear reactors to generate energy.
Nuclear Fission:
It involves splitting of heavy atomic nuclei into lighter elements. This process is commonly used in nuclear reactors to generate energy.

Particle Bombardment:
Particle bombardment is another method where high-energy particles are directed at target atoms to induce nuclear reactions and create new elements.

Q.2 (Ex Q.5 (ii)) A system just like our solar system exists in an atom. Comment on this statement.
Ans. The idea that an atom is similar to a mini solar system is helpful to explain atomic structure.
In an atom, there is a nucleus at the center, much like the sun in our solar system and electrons revolving around the nucleus like planets orbiting around the sun. This model helps visualize how electrons are arranged around the nucleus. Although the concept of mini solar system is helpful to describe the atomic structure, it also has the following contradictions:
(i) In solar system, planets follow predictable orbits around the sun but electrons around the nucleus do not follow fixed paths but follow probability patterns.
(ii) The solar system is governed by gravitational forces but atomic structures are maintained by electromagnetic and nuclear forces.
(iii) Electrons in an atom can jump between discrete energy levels, emitting and absorbing energy in a process but this jumping does not exist in our solar system.

SLO Based Additional Long Questions
Q.1. How are cathode rays produced? What are their major characteristics?

Ans. Experiment:
A discharge tube is a hard glass tube provided with two metallic electrodes and a vacuum pump to evacuate the gas present in it. When a very high voltage is applied to a gas at a very low pressure present in a glass tube, the glass surface behind the positive electrode started to glow due to the rays emitted from the cathode. These rays were named as **cathode rays**.

Characteristics of Cathode Rays:
In 1897, British physicist Joseph John Thomson studied the properties of cathode rays by passing them through oppositely charged electric plates.

(i) Cathode rays bent towards the positively charged plate showing that they carry negative charge.

(ii) Thomson used the findings of his experiments to calculate the mass to charge ratio of cathode rays which finally proved that cathode rays are, in fact, negatively charged material particles.

(iii) These particles were later named as **electrons**. It was also shown that electrons are subatomic particles of all elements.

Q.2. Explain how canal rays were produced?

Ans. Discovery:
The presence of positively charged particles in an atom had been first observed by E. Goldstein in 1886. It was based on the concept that atoms are electrically neutral having same number of positive and negative charges.

Experiment:
He performed a series of experiments with a gas-discharge tube having a perforated cathode. A new type of rays were produced from the anode which moved towards the cathode. He called these new rays as **canal rays** or **anode rays**.

Properties:

(i) The properties of these rays seemed to vary depending on the gas used in the discharge tube. In fact, what he discovered was gas ions and this also included hydrogen ions (H^+). Goldstein at that time knew nothing about its significance.

(ii) In 1917, Rutherford performed experiments which proved that the hydrogen nucleus is present in other nuclei. Rutherford thought that a hydrogen nucleus or a proton must be the fundamental building block of all nuclei and also possibly a new fundamental particle as well.

Q.3. What are isotopes? Explain the isotopes of hydrogen and carbon.

Ans.

Isotopes (Iso means 'same', topes means 'position in Periodic Table')

Definition:
Atoms of the same element having different number of neutrons in their nuclei are called **isotopes**.

Properties of isotopes:
Chemical properties of the elements are determined by the number of electrons, all isotopes will show almost the same chemical behavior, although their physical properties may be different.

Isotopes of Carbon:
Element carbon has three isotopes as its atoms have six, seven and eight neutrons in their nuclei. These isotopes are represented as ^{12}C, ^{13}C, ^{14}C.

Isotope	Protons	Neutrons
^{12}C	6	6
^{13}C	6	7
^{14}C	6	8

Isotopes of Hydrogen:
Hydrogen exists as three isotopes: Hydrogen (Protium), Deuterium and Tritium represented by ^{1}H, ^{2}H and ^{3}H.

Isotope	Protons	Neutrons	Electrons
^{1}H (Protium)	1	0	1
^{2}H (Deuterium)	1	1	1
^{3}H (Tritium)	1	2	1

Exercise Short Questions

Q.1 Why is it said that almost all the mass of an atom is concentrated in its nucleus?

Ans. Almost all the mass of an atom is concentrated in its nucleus because the nucleus contains protons and neutrons, which have much greater mass as compared to the electrons that orbit around the nucleus. Protons and neutrons are approximately 1836 times more massive than electrons.

Q.2 Why are elements different from one another?

Ans. Elements are identified by their atomic numbers. Elements are different from one another because each element has a unique atomic number and different properties. The number of electrons, protons and neutrons in an atom determine its chemical behavior which in turn distinguishes one element from another.

Q.3 How many neutrons are present in $^{210}_{83}Bi$?

Ans. Each bismuth atom will have 83 protons and 83 electrons. The number of neutrons in bismuth will be calculated as follows:

n = A - Z

n = 210 - 83 = 127

So, each bismuth atom will have **127 neutrons** in its nucleus.

Q.4 Why is tritium (^{3}H) a radioactive element?

Ans. Tritium is a radioactive isotope of hydrogen because it has an unstable nucleus. Tritium undergoes radioactive decay, emitting low energy beta radiations. Tritium has two neutrons, one proton and one electron making it heavier than the other two isotopes of hydrogen (Protium and Deuterium).

Q.5 How can an atom absorb and evolve energy?

Ans. An atom can evolve or absorb energy through a process called **electron transition**. When an electron in an atom jumps from low energy orbit to high energy orbit, it **absorbs** energy and when it jumps back from high energy orbit to low energy orbit, it **evolves** energy. This energy is evolved or absorbed in the form of electromagnetic radiation, such as light or heat.

Q.6 Calculate the number of neutrons, protons and electrons in the following atoms:

(i) $^{195}_{78}Pt$

Solution:

Each Pt atom will have **78 protons** and **78 electrons**.

The number of neutrons in Pt will be calculated as follows:

n = A - Z

n = 195 - 78 = 117

So, each Pt atom will have **117 neutrons, 78 protons and 78 electrons**.

(ii) $^{55}_{25}Mn$

Solution:

Each Mn atom will have **25 protons** and **25 electrons**.

The number of neutrons in Mn will be calculated as follows:

n = A - Z

n = 55 - 25 = 30

So, each Mn atom will have **30 neutrons, 25 protons and 25 electrons**.

(iii) $^{127}_{53}I$

Solution:

Each $^{127}_{53}I$ atom will have **53 protons** and **53 electrons**.

The number of neutrons in $^{127}_{53}I$ will be calculated as follows:

n = A - Z

n = 127 - 53 = 74

So, each $^{127}_{53}I$ atom will have **74 neutrons, 53 protons and 53 electrons**.

Q.7 Why isotopes of an element show same chemical properties while their physical properties are different?

Ans.

(i) Isotopes have same chemical properties because they have same electronic configuration and have same atomic number.

(ii) Isotopes have different physical properties because they have different mass numbers.

Q.8 Why does the radioactive isotope emit radiation? Give an example of a radioactive isotope which disintegrates to give a stable atom.

Ans. Several isotopes of the same elements exist whose nuclei are unstable. They are high in energy. They emit excess energy in the form of radiation. This process of emission is called radioactivity and the isotope which emits energy is called radioactive isotope. Every element has one or more radioactive isotope.

Example:

$^{210}_{83}Bi \rightarrow {}^{210}_{81}Tl$ + Energy

Q.9 How would you compare the masses of the atoms of C, Mg and Cl?
Ans.
The atomic mass of carbon is **12.01 amu**
The atomic mass of magnesium is **24.30 amu**
The atomic mass of chlorine is **35.45 amu**
To compare their masses:

- Mass of Mg / Mass of C = 24.30 / 12.01 = **2.02** → Mg atom is **2.02 times heavier** than C atom.
- Mass of Cl / Mass of C = 35.45 / 12.01 = **2.95** → Cl atom is **2.95 times heavier** than C atom.
- Mass of Cl / Mass of Mg = 35.45 / 24.30 = **1.45** → Cl atom is **1.45 times heavier** than Mg atom.

Carbon is the lightest atom among these three atoms.

Q.10 Calculate the relative atomic mass of lead (Pb). Isotopic abundances of isotopes are 2.0%, 24.0%, 22.0% and 52.0% for ^{204}Pb, ^{206}Pb, ^{207}Pb and ^{208}Pb respectively.
Ans.
Relative atomic mass of Lead (Pb)
= (2×204 + 24×206 + 22×207 + 52×208) / 100
= 207.22 amu

Q.11 Have you ever thought why some elements are so different from one another?
Ans. Sulphur looks very different from gold which, in turn, is very different from bromine. Similarly iron is a heavy metal while aluminum and zinc are light metals. Metals are mostly lustrous while non-metals like sulphur and carbon appear dull. The difference in the properties of elements is due to difference in the properties of their constituent atoms.

Structure of Atom
Q.12 Define Nuclear force.
Ans. The strong attractive force that binds protons and neutrons together. This force is stronger than electrostatic or magnetic forces. This force exists between:

- Neutrons and neutrons
- Protons and protons
- Neutrons and protons

Q.13 Why is the mass of electron neglected for determining the mass of an atom?
Ans. Protons and neutrons have roughly the same mass, around 1 amu. This mass contributes significantly to the total mass of the atom. Electrons have much less mass — the mass of electron is about 1836 times less than the mass of proton and neutron — so their contribution to the total mass of an atom is usually negligible.

Q.14 How many times is cesium bigger than Helium?
Ans. The largest atom cesium is approximately **nine times bigger** than the smallest atom helium.

Q.15 What is the origin of Cathode and Anode Rays?

Ans. Cathode rays are so named because they are emitted by the cathode in a discharge tube. A very high electrical potential of thousands of volts was applied in the discharge tube which ionized the residual gas atoms present in the tube. The positive ions thus produced travelled towards the cathode as anode or canal rays. When they collided with the cathode they knocked electrons out of its surface. This stream of electrons was called **cathode rays**.

Q.16 What is the structure of an atom?
Ans. Lord Rutherford, in 1911, carried out an experiment in which he hit a stream of alpha particles to a very thin gold foil. From this experiment he concluded that an atom has two portions:

1. A tiny central portion which he called as **nucleus**
2. A relatively large area surrounding this, which he called **extra nuclear portion**

The electrons are present in this extra nuclear portion in the form of cloud around the nucleus.

Q.17 Who first gave the idea of atom? Briefly describe contribution of Democritus.
Ans. Democritus declared that all matter is made of tiny particles. He named this particle as **atom**, a particle that cannot be further subdivided.

Q.18 Who discovered an electron, a proton and a neutron?
Ans.

- **(i)** Goldstein discovered positively charged particles called **protons** in 1886.
- **(ii)** Thomson found the negatively charged particles known as **electrons** in 1897.
- **(iii)** Chadwick discovered **neutron** in 1932.

Q.19 How does electron differ from a neutron?

Electron	Neutron
It is the negatively charged particle.	It is the neutral particle.
It revolves around the nucleus.	It is present in the nucleus.
Mass of electron is 5.486×10^{-4} amu.	Mass of neutron is 1.0087 amu.

Q.20 Differentiate between shell and sub-shell with examples.

Shell	Sub Shell
Each principle energy level in which an electron revolves around nucleus is called shell.	Each shell further contains one or more sub levels called sub shells.
These are represented by K, L, M, N etc.	These are represented by s, p, d, f.

Q.21 What are sub-atomic particles?
Ans. Sub-atomic particles are the fundamental particles that make up atoms. The three main sub-atomic particles are:

Particle	Mass (kg)	Charge
Proton	1.6726×10^{-27}	+1
Neutron	1.6750×10^{-27}	0
Electron	9.109×10^{-31}	-1

Q.22 Compare the size of nucleus with the size of atom.
Ans. Although the nucleus is less than one hundred-thousandth (1/100,000) of the size of the atom, it contains more than 99.9% of the mass of the atom.

Discovery of Electrons
Q.23 How were cathode rays produced?
Ans. A discharge tube is a hard glass tube provided with two metallic electrodes and a vacuum pump to evacuate the gas present in it. When a very high voltage is applied to a gas at a very low pressure present in a glass tube, the glass surface behind the positive electrode started to glow, due to the rays emitted from the cathode. These rays were named as **cathode rays**.

Q.24 Discuss characteristics of cathode rays.
Ans. In 1897, British physicist Joseph John Thomson studied the properties of cathode rays by passing them through oppositely charged electric plates.

(i) Cathode rays bent towards the positively charged plate showing that they carry negative charge.
(ii) Thomson used the findings of his experiments to calculate the mass to charge ratio of cathode rays which finally proved that cathode rays are, in fact, negatively charged material particles.
(iii) These particles were later named as **electrons**. It was also shown that electrons are the subatomic particles of all elements.

Atomic Number and Mass Number
Q.25 How are ions and isotopes formed?
Ans. Changing the number of electrons of an element forms **ions**, while changing the number of neutrons of an element forms **isotopes**.

Q.26 Calculate the number of neutrons, protons and electrons in barium ($^{137}_{56}$Ba).
Solution:
Each barium atom will have **56 protons** and **56 electrons**.
The number of neutrons in barium will be calculated as follows:
n = A - Z
n = 137 - 56 = 81
So each $^{137}_{56}$Ba atom will have **81 neutrons, 56 protons and 56 electrons**.

Q.27 Define Proton number/Atomic number.

Ans. Proton number refers to the number of protons in the nucleus of an atom. It is also known as the **atomic number** and is indicated by the symbol **"Z"**.
For example: There is only one proton in the nucleus of H atom; therefore its atomic number is **1**.

Q.28 Define Nucleon number/Atomic mass.
Ans. The sum of total number of protons and neutrons in an atom is known as its **mass number** or **nucleon number**. It is represented by **A**.
Formula:
A = Z + n or **n = A - Z**
For Example: Mass of 1st isotope of hydrogen is **1**.

Q.29 Give an example of a synthetic element.
Ans. Copernicium (Cn) is a synthetic element and it was discovered in 1996. This metal turns into a gas at room temperature.

Isotopes and their Masses
Q.30 Define Isotopes.
Ans. Isotopes are atoms of an element that have the same atomic number but different mass number. This is because atoms of an element can differ in the number of neutrons.
Example: ^{1}H, ^{2}H, ^{3}H are isotopes of hydrogen.

Q.31 What are the isotopes of hydrogen?
Ans. Hydrogen has three isotopes:

- **Hydrogen-1 (Protium)** - Symbol: ^{1}H, has no neutron
- **Hydrogen-2 (Deuterium)** - Symbol: ^{2}H, has one neutron
- **Hydrogen-3 (Tritium)** - Symbol: ^{3}H, has two neutrons

Q.32 What do you know about isotopes of carbon?
Ans. Carbon has three isotopes:

- **Carbon-12 (^{12}C)** - 6 protons, 6 neutrons (most abundant ~98.9%)
- **Carbon-13 (^{13}C)** - 6 protons, 7 neutrons (~1.1%)
- **Carbon-14 (^{14}C)** - 6 protons, 8 neutrons (radioactive, trace amounts)

Q.33 Define radioactivity and radioactive isotopes.
Ans. The isotopes of the same element do not have the same physical properties. Several isotopes of the same elements exist whose nuclei are unstable. They emit excess energy in the form of radiation. This process of emission is called **radioactivity** and the isotope which emits energy is called **radioactive isotope**.
For example: $^{238}_{92}U$ is a radioactive isotope of uranium.

Relative Atomic Mass
Q.34 Define relative isotopic masses.
Ans. An element usually consists of a few different isotopes with different mass numbers. These mass numbers are called **relative isotopic masses**. Each isotope will also have its own naturally occurring abundance which is called **isotopic abundance**.

Q.35 Define atomic mass unit. Why is it needed?

Ans. The unit for relative atomic mass is called **atomic mass unit**. Its symbol is **amu**. One atomic mass unit is the mass of 1/12th of one atom of carbon-12 isotope.
Need: The mass of an atom is too small to be determined practically. That's why to determine the atomic mass of various elements, atomic mass unit is needed.

Q.36 Define relative isotopic mass. How can relative atomic mass be determined?
Ans. An element usually consists of different isotopes. The relative atomic mass of an element can be calculated from the relative isotopic masses (m) and isotopic abundances (p) by formula:
Relative atomic mass = $(m_1p_1 + m_2p_2 + m_3p_3) / 100$

Q.37 Calculate relative atomic mass of carbon.
Ans. The relative atomic mass is a weighted average of all the naturally occurring isotopes of an element, taking into consideration of their natural abundance.
Relative atomic mass of C = (98.8 × 12 + 1.1 × 13 + 0.009 × 14) / 100
= (1185.6 + 14.3 + 0.126) / 100
= 1200.026 / 100
= 12.00026 amu

Q.38 Calculate the relative atomic mass of Krypton (Kr). Isotopic abundances of isotopes 2.0%, 12.0%, 12.0%, 57.0%, and 57.0% are for masses 80, 82, 83, 84, 85 respectively.
Ans.
Relative atomic mass of krypton
= (80×2.0 + 82×12.0 + 83×12.0 + 84×57.0 + 85×57.0) / 100
= 83.7 amu

Q.39 Calculate the relative atomic mass of light isotope of chlorine when its relative atomic mass is taken as 35.45.
Ans.
Relative isotopic abundance of Cl-37 = 24.23%
Relative isotopic abundance of light isotope of chlorine = 75.77%
Relative atomic mass of chlorine = 35.45
35.45 = (Cl × 75.77 + 37 × 24.23) / 100
3545 = Cl × 75.77 + 896.51
2648.49 = Cl × 75.77
Cl = 34.95
Relative atomic mass of light isotope of chlorine is **34.95**.

Q.40 What is meant by carbon dating or radiocarbon dating?
Ans. Radiocarbon dating is a method for finding out the age of a historical object containing organic material with the help of radioactive isotope of carbon (^{14}C). The method involves measuring the proportion of ^{14}C in a sample from a dead plant or animal like a piece of wood or a bone which provides information that can be used to calculate when an animal or plant died. The older the sample is, the less ^{14}C is to be detected.

Q.41 What makes gallium unique from other metals?
Ans. Gallium has many interesting properties:

- Its melting point is below body temperature so it is liquid at room temperature.
- It has water-like viscosity.
- It does not evaporate easily.

Discovery of Neutron

Q.42 How are the particles arranged in a tiny place? What is the structure of an atom?

Ans. Lord Rutherford, in 1911, carried out a remarkable experiment in which he hit a stream of special type of particles to a very thin gold foil. From this experiment he concluded that an atom has two portions:

1. A tiny central portion which he called as **nucleus**
2. A relatively large area surrounding this, which he called **extra nuclear portion**

It was also discovered that almost all the mass of an atom is concentrated in the nucleus because both the heavy particles i.e. protons and neutrons are found to be present here. In the nucleus these two particles are held together by a **strong nuclear force**.

Bohr's Atomic Model

Q.43 Write the contribution of Niel Bohr.

Ans. In 1913, Niel Bohr proposed a model for the hydrogen atom which is called **Bohr's atomic model**. According to this model:

- The electron can revolve around the nucleus of the atom in specific paths called **orbits** or **shells**.
- When the electron is revolving in one of these orbits, its energy is **fixed**.
- When the electron is present in the orbit which is closest to the nucleus, its energy is **minimum** and it is called the **ground state** of the atom.

Q.44 How can atoms be seen?

Ans. The size of an atom is so small that it is not possible to see it with naked eye. However, a **transmission electron microscope (TEM)** can be used to see atoms.

Q.45 How to find out the number of electrons in a shell?

Ans. To find out the number of electrons which can be accommodated in these extra-nuclear shells, the scientists have devised a formula called **$(2n^2)$ formula** where n can have values 1, 2, 3... and so on and they represent the number of shells. Shells have also been named as K, L, M, N ... and so on.

Shell	n	Maximum Electrons ($2n^2$)
K	1	2
L	2	8
M	3	18
N	4	32

Q.46 How many times is cesium bigger than helium?

Ans. The largest atom cesium is approximately **nine times bigger** than the smallest atom helium.

Q.47 How many atoms does our body replace every year?
Ans. Every year, our body replaces about **98%** of its atoms.

Constructed Response Questions
Q.1 (Ex Q. 3 (i)) Why does the energy of electron increase as we move from first shell to second shell?
Ans. The energy of an electron increases as we move from the first to the second shell because the second shell is farther away from the nucleus which means that electron in the second shell has higher energy as compared to the electron in the first shell. This increase in distance from the nucleus results in a higher energy level for electron in outer shell.

Q.2 (Q. 3 (ii)) Why is it needed to lower the pressure of the gas inside the discharge tube?
Ans. Lowering the pressure of the gas inside the discharge tube is necessary because it helps to create a vacuum. This vacuum provides minimum opposition to the electrons emitting from the electrode creating smoothly moving cathode/canal rays.

Q.3 (Q. 3 (iii)) What is the classical concept of an electron? How has this concept changed with time?
Ans. The classical concept of an electron is that electrons being charged particles should release or emit energy continuously and they should ultimately fall into the nucleus. Electron revolve around the nucleus of an atom similar to planets revolve around the sun in the solar system.
However, as scientific knowledge advanced, the concept of electron evolved. Now, it is considered that electrons behave like particles as well as waves. Electrons are now described by **wave functions** that represents the **probability** of finding an electron in a particular region around the nucleus rather than following a definite path like a planet in orbit. This change in concept has led to a more convinced understanding of the behavior of electrons in atoms and molecules.

Q.4 (Q. 3 (iv)) Why are the nuclei of the radioactive elements unstable?
Ans. The nuclei of radioactive elements are unstable because they contain an imbalance of protons and neutrons which leads to an excess of energy within the nucleus. This imbalance causes the nucleus to undergo radioactive decay in order to become more stable. During radioactive decay, the nucleus emits energy in the form of radiation to achieve a more balanced and stable configuration.

Q.5 (Q. 3 (v)) During discharge tube experiments, how did the scientists conclude that the same type of electrons and protons are present in all the elements?
Ans. During discharge tube experiments, scientists observed that the properties of the electrons and protons were the same regardless of the element being studied. They concluded that the same type of electrons and protons are present in all elements. From discharge tube experiments, scientists suggested that electrons are negatively charged particles and protons are positively charged particles. These fundamental particles are consistent across different elements.

Multiple Choice Questions (with Corrections)

1. How many electrons can be accommodated at the most in the third shell of the elements?

- (a) 8
- **(b) 18** ✓
- (c) 10
- (d) 32

2. What information was obtained from discharge tube experiments?

- (a) Structure of atom was discovered
- (b) Neutrons and protons were discovered
- **(c) Electrons and protons were discovered** ✓
- (d) Presence of nucleus in an atom was discovered

3. Why have isotopes not been shown in the periodic table?

- (a) Periodic table cannot accommodate a large number of isotopes of different elements.
- (b) Some of the isotopes are unstable and they give rise to different elements.
- **(c) All the isotopes have same atomic number, so there is no need to give them separate places.** ✓
- (d) Isotopes do not show periodic behavior

4. Which particle is present in different number in the isotopes?

- (a) Electron
- **(b) Neutron** ✓
- (c) Proton
- (d) Both neutron and electron

5. In which isotope of oxygen are there equal numbers of protons, electrons and neutrons?

- (a) ^{17}O
- **(b) ^{16}O** ✓
- (c) ^{18}O
- (d) None of these

6. What will be the relative atomic mass of nitrogen given the abundances of its two isotopes, ^{14}N and ^{15}N are 99.64% and 0.35%?

- **(a) 14.0210** ✓
- (b) 14.0021
- (c) 14.2100
- (d) 14.1200

7. How is radiocarbon dating useful for archaeologists?

- **(a) It helps determine the age of organic matter.** ✓
- (b) It helps determine the composition of matter.
- (c) It helps determine the usefulness of matter.
- (d) It helps determine whether the matter is radioactive or not.

8. What keeps the particles present in the nucleus intact?

- **(a) Particles are held together by strong nuclear force.** ✓
- (b) Particles are held together by weak nuclear force.
- (c) Particles are held together by electrostatic force.
- (d) Particles are held together by dipolar force.

9. How do electrons keep themselves away from the oppositely charged nucleus?

- (a) By keeping themselves stationary
- **(b) By revolving around the nucleus** ✓

- (c) Due to their wave-like nature
- (d) A magnetic field around the nucleus keeps them away

10. Rubidium consists of two isotopes ^{85}Rb and ^{87}Rb. The percent abundance of the light isotope is 72.2%. What is the percent abundance of the heavier isotope? Its atomic mass is 85.47.

- (a) 15%
- **(b) 27.8%** ✓
- (c) 37%
- (d) 72%

Structure of Atom

11. N shell has sub-shells:

- (a) 1s, 2s
- (b) 2s, 2p
- (c) 3s, 3p, 3d
- **(d) 4s, 4p, 4d, 4f** ✓ *(Corrected: N shell has s, p, d, f subshells)*

12. A sub-shell that can accommodate 6 electrons is:

- (a) s
- (b) d
- **(c) p** ✓
- (d) f

13. John Dalton put forward his atomic theory:

- (a) 1800
- (b) 1805
- (c) 1903
- **(d) 1803** ✓

14. Rutherford used a gold foil in his experiment, which had a thickness of:

- (a) 0.002 cm
- **(b) 0.00004 cm** ✓
- (c) 0.0001 cm
- (d) 0.001 cm

15. Who performed the first experiment to split an atom?

- (a) Shoddy
- **(b) Rutherford** ✓
- (c) Bohr
- (d) Newton

16. According to Rutherford's atomic theory, atom should produce:

- (a) Line spectrum
- **(b) Continuous spectrum** ✓
- (c) Both a & b
- (d) None of these

17. Quantum means:

- (a) Variable energy
- **(b) Fixed energy** ✓
- (c) High energy
- (d) Minimum energy

18. The mass of proton is:

- **(a) 1.6726×10^{-27} kg** ✓

- (b) 1.6749×10^{-27} kg
- (c) 9.11×10^{-31} kg
- (d) None of these

19. The mass of neutron is:

- (a) 1.6726×10^{-27} kg
- **(b) 1.6750×10^{-27} kg** ✓
- (c) 9.11×10^{-31} kg
- (d) None of these

20. The mass of electron is:

- (a) 1.6726×10^{-27} kg
- (b) 1.6749×10^{-27} kg
- **(c) 9.109×10^{-31} kg** ✓
- (d) None of these

21. Protons are deflected toward _____ plate:

- (a) Positive
- **(b) Negative** ✓
- (c) both a and b
- (d) None of these

22. The nucleus of an atom is composed of:

- (a) Electrons
- (b) Electrons and protons
- (c) Electrons and neutrons
- **(d) Protons and neutrons** ✓

23. How many electrons can be accommodated in s subshell?

- **(a) 2** ✓
- (b) 6
- (c) 10
- (d) 14

24. Number of electrons that can be accommodated in f-subshell:

- (a) 2
- (b) 6
- (c) 10
- **(d) 14** ✓

25. Which subshells are present in L-shell?

- **(a) s & p** ✓
- (b) Only s-subshell
- (c) Only p-subshell
- (d) None of these

26. How many subshells are there in M-shell?

- (a) 2
- **(b) 3** ✓ *(s, p, d)*
- (c) 4
- (d) 5

27. N-shell contains number of subshells:

- (a) 1
- (b) 2
- (c) 3

- **(d) 4** ✓

28. An element has 5 electrons in M-shell. Its atomic number is:

- (a) 5
- (b) 10
- **(c) 15** ✓ *(2+8+5 = 15)*
- (d) 20

29. d-subshell can accommodate maximum electrons:

- (a) 2
- (b) 6
- **(c) 10** ✓
- (d) 14

30. The removal of electron from a neutral atom gives rise to:

- (a) Molecular anion
- (b) Molecular cation
- (c) Anion
- **(d) Cation** ✓

31. How many electrons can be accommodated at the most in the third shell of the elements?

- (a) 8
- **(b) 18** ✓
- (c) 10
- (d) 32

Atomic Number and Mass Number

32. Number of neutrons in $^{27}_{13}Al$ are:

- (a) 13
- **(b) 14** ✓ *(27-13=14)*
- (c) 27
- (d) 15

33. Number of protons in the nucleus of an atom is called:

- (a) Mass number
- **(b) Atomic Number** ✓
- (c) Electron number
- (d) Mass Unit

34. Atom is electrically:

- (a) Positive particle
- (b) Negative particle
- **(c) Neutral particle** ✓
- (d) None of these

35. Atomic number is represented by:

- **(a) Z** ✓
- (b) A
- (c) P
- (d) At

36. $^{238}_{92}U$ has number of neutrons:

- (a) 92
- (b) 238

- **(c) 146** ✓ *(238-92=146)*
- (d) 330

37. Mass number is represented by:

- **(a) A** ✓
- (b) Z
- (c) M
- (d) Na

Isotopes and their Masses

38. Which of the following statement is not correct about isotopes?

- (a) they have same atomic number
- (b) they have same number of protons
- (c) they have same chemical properties
- **(d) they have same physical properties** ✓

39. Which isotope is used in nuclear reactors?

- (a) U-234
- (b) U-238
- **(c) U-235** ✓
- (d) all of these

40. Chlorine has two isotopes, both of which have:

- (a) same mass number
- (b) same number of neutrons
- (c) different number of protons
- **(d) same number of electrons** ✓

41. Which isotope is commonly used to irradiate cancer cells?

- (a) iodine-123
- (b) Carbon-14
- **(c) Cobalt-60** ✓
- (d) iodine-131

42. Number of isotopes of hydrogen is:

- (a) 2
- **(b) 3** ✓
- (c) 4
- (d) 5

43. Symbol for Deuterium is:

- (a) ^{1}H
- **(b) ^{2}H** ✓
- (c) ^{3}H
- (d) H

44. ^{13}C and ^{14}C are both present in nature:

- (a) 0.1%
- (b) 0.9%
- **(c) 1.1%** ✓
- (d) 1.5%

45. The percentage of $^{235}_{92}U$ found in nature is:

- (a) 97%
- (b) 98%

- **(c) 0.72%** ✓
- (d) 0.62%

46. Which isotope is used for diagnosis of goiter?

- **(a) Iodine-131** ✓
- (b) Cobalt-60
- (c) P-32
- (d) Sr-90

47. Carbon-14 is used for the:

- **(a) Age determination of old objects** ✓
- (b) Growth of bones
- (c) Diagnosis of goiter
- (d) All of these

48. Mass of Proton in amu is:

- **(a) 1.0073** ✓
- (b) 1.0087
- (c) 1.672×10^{-24}
- (d) None of these

49. Predict the boiling point of heavy water (D_2O).

- **(a) 101.4°C** ✓
- (b) 98.2°C
- (c) 100°C
- (d) 105.4°C

50. What will be the relative atomic mass of hydrogen given the abundances of its two isotopes, 99.9844% and 0.0156%?

- **(a) 1.0078** ✓
- (b) 1.0784
- (c) 1.0800
- (d) 1.0700