Chapter # 2
Atomic Structure

Student Learning Outcomes

After studying this chapter, students will be able to:

- Explain the structure of the atom as a central nucleus containing neutrons and protons surrounded by electrons in shells.
- State that, orbits (shells) are energy levels of electrons and a larger shell implies higher energy and greater average distance from nucleus.
- State that electrons are quantum particles with probabilistic paths whose exact paths and locations cannot be mapped (with reference to the uncertainty principle)
- Explain that a nucleus is made up of protons and neutrons held together by strong nuclear force.
- Explain that an atomic model is an aid to understand the structure of an atom.
- State the relative charge and relative masses of a subatomic particles (an electron, proton and neutron)
- Interpret the relationships between a subatomic particle, their mass and charge.
- Illustrate the path that positively and negatively charged particles would take under the influence of a Uniform Electric Field.
- Define proton number / atomic number as the number of protons in the nucleus of an atom.
- Explain that the proton number is unique to each element and used to arrange elements in periodic table
- State the radioactivity can change the proton number and alter an atom's identity
- Define nucleon number / atomic mass as sum of number of protons and neutrons in the nucleus of an atom.
- Define isotopes as different atoms of the same element that have same number of protons but different neutrons.
- State that isotopes can affect molecular mass but not chemical properties of an atom.
- Determine the number of protons and neutrons of different isotopes
- Define relative atomic mass as the average mass of isotopes of an element compared to 1/12th of mass of an atom of Carbon - 12
- State that isotopes can exhibit radioactivity
- Discuss the importance of isotopes using carbon dating and medical imaging as examples. Describe the formation of positive (cation) and negative (anion) ions from atoms.
- Interpret and use the symbols for atoms and ions
- Calculate relative atomic mass of an element from relative masses and abundance of isotopes.
- Calculate the relative mass of an isotope given relative atomic mass and abundance of all stable isotopes.

Q1. How the elements are made up of?

Ans. All the elements are made up of atoms.

Q2. Why elements are so different from one another?

Ans. Elements are quite different from one another.

Iron looks different from gold which, in turn, is very different from aluminium or zinc.

Iron is heavy a metal while aluminium is light metal, metals, are lustrous while non-metals are dull.

Reason : The difference in the properties of elements is due to the differenee in the properties of their constituent atoms.

Different elements look different

Q3. Who proposed that atoms are indivisible?

Ans. In 1808, an English chemist John Dalton proposed that atoms are indivisible.

In other words, according to him, it was not possible to divide atoms to smaller particles.

Q4. Discuss the discovery of electron.

OR How cathode rays are produced? Write down their properties. How their production leads to the discovery of electron?

Ans. The electron was discovered by the passage of electric current through gases at very low pressure in a also charge tube experiment.

Construction of Discharge tube: 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 evacuated 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.

Properties of cathode-rays: In 1897, British physicist Joseph John Thomson studied the properties of cathode rays by passing them through the oppositely charged electric plates. It was observed that cathode rays bent towards the positively charged plate showing that

they carry negative charge. Thomson also installed two magnets on either side of the discharge tube and noticed that cathode rays were also diverted by the magnetic field. 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. These particles were later named as electrons.

Fig 2.2 Discharge Tube Experiment Cathode Rays

Q5. Who studied the properties of cathode rays?

Ans. In 1897; British physicist Joseph John Thomson studied the proportion of cathode rays.

Q6. Describe the discovery of proton.

Ans. 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. 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 anode rays. The properties of these rays seemed to vary depending on the gas used in the discharge tube the simplest positive rays were obtained when the discharge tube contain hydrogen gas. These positive rays or hydrogen ions are named as protons. The mass of positively charged particle was found equal to that of a proton or simple multiple of it.

Conclusion: On the basis of these properties it was concluded that like electron, proton is also fundamental particles of an atom.

Q7. What is origin of cathode and anode rays in discharge tube?

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 traveled 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.

Q8. Write down the discovery of Neutron.

Ans. In 1933, neutron was also discovered, which is known to carry no charge. The mass of a neutron is almost the same as that of a proton. These three particles i.e. electron, proton and neutron were given the name fundamental particles and are shown to be present in all atoms irrespective of the fact that these atoms behave very different from one another. It was, however, also shown that the number of these particles is different in different atoms.

Q9. How Rutherford concluded that atoms has two portions?

Ans. In 1911, Lord Rutherford 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. A tiny central portion which he called as nucleus, and relatively large area surrounding this, which he called extra nuclear portion.

Q10. Where whole the mass of atom is concentrated?

Ans. It was also discovered in Rutherford's experiment that whole mass of an atom is concentrated in the nucleus, because both the heavy particles (protons and neutrons are present in nucleus.

Q11. Define orbit or shell.

Ans. The fixed circular (oval) path at which electrons revolve around the nucleus is called an orbit or shell. The shells are also known as energy levels.

Q12. What is first shell?

Ans. The shell which is nearest to the nucleus is called first shell. It is also known as K-shell.

Q13. What are sub-shells? Write down their types.

Ans. Sub-shells: Each shell is further sub-divided into sub-shells or orbitals. These sub-energy levels are called sub-shells.

Type of sub-shells

There are four types of sub-shells:

1. s – sub-shell
2. p – sub-shell
3. d – sub-shell
4. f – sub-shell

Q14. Write down the number of electrons in each sub-shells.

Ans. Number of electrons in each sub-shell:

Sub-shell		Maximum Electrons
s	=	2
p	=	6
d	=	10
f	=	14

Q15. Write down the number of sub-shells in various shells.

Ans. The number of sub-shells present in a shell is equal to the value of "n" for that shell.

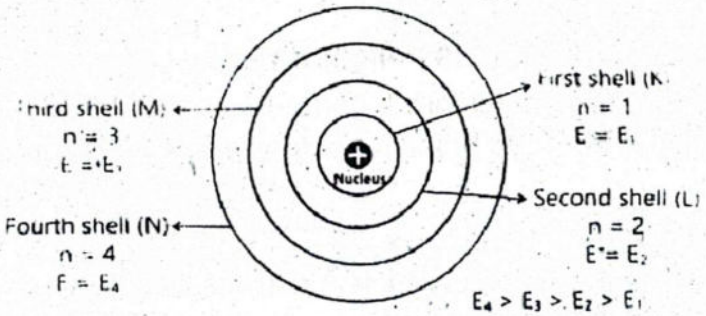
n-value	Shells	Sub-shells
1	First shell (K-shell)	only s
2	Second shall (L-shell)	s, p
3	Thirdshall (M-shell)	s, p, d
4	Forth shell (N-shell)	s, p, d, f

Q16. What do you know about the location of electrons around nucleus?

Ans. According to modern approach, electrons are like charged clouds whose location around the nucleus cannot be predicted with one hundred percent certainty. There is a certain probability of finding electrons at a certain probable distance from the nucleus.

Q17. Draw a diagram to show the energy of electrons in various shells.

Ans. Electrons present in each shell have a fixed energy.



Q18. Write down the masses and charges of sub-atomic particles.

Ans.

Particle	Charge	Mass
Electron	-1.6022×10^{-19}C	9.109×10^{-31} Kg
Proton	$+1.6022 \times 10^{-19}$C	1.673×10^{-27} Kg
Neutron	0.0	1.675×10^{-27} Kg

Q19. How many times cesium is bigger than helium?

Ans. Cesium is approximately nine times bigger than helium atom.

Q20. Define electronic configuration. Write down the formula for it.

Ans. Electronic Configuration: The arrangement of electrons around the nucleus is called electronic configuration.

Formula for electronic configuration = $2n^2$

Where "n" shows number of shells. According to formula

No. of electrons in first shell (K–shell) = $2n^2 = 2(1)^2 = 2$

No. of electrons in 2nd shell (L–shell) = $2n^2 = 2(2)^2 = 8$

No. of electrons in 3rd shell (M–shell) = $2n^2 = 2(3)^2 = 18$ and so on.

Q21. Write down the number of electrons which can be accomodated in each sub-shells.

Ans. Number of electrons in sub-shells.

Sub-shell	Maximum Electrons
s	2
p	6
d	10
f	14

Q22. Write down the names of fundamental particles of all types of matter.

Ans. Electrons, protons and neutrons are called fundamental particles of all type of atoms.

Q23. What is meant by atomic number? Give examples.

Ans. Atomic number: The number of protons present in the nucleus of an atom is called atomic number.

Representation: It is represented by Z.

Importance: Atomic number of an element is unique to that element, and the element is identified by this number.

Examples:

Atomic number of sodium = 11
Atomic number of carbon = 6
Atomic number of chlorine= 17

Q24. How the elements are arranged in the periodic table?

Ans. In the periodic table, the elements are arranged in increasing order of their atomic numbers.

Q25. Why the atom as a whole is electrically neutral?

Ans. Atom as a whole is electrically neutral because the number of electrons in an atom is always equal to the number of protons.

Q26. What is meant by nucleon number or mass number? How it is represented? Give examples.

Ans. **Nucleon number or mass number:** The total number of protons and neutrons present in the nucleus an atom is called its nucleon number or mass number.

Representation: It is represent by **A.**

Examples:

Mass number of sodium = 23
Mass number of calcium = 40
Mass number of potassium = 39

Q27. Why the mass of electron is not included in mass number?

Ans. The mass of electron being very small is not included in the mass number.

Q28. How the atomic number and mass number of an element are written?

Ans. The atomic number is written as a left subscript, while the mass number is written as a left superscript to the chemical symbol of the element.

Examples:

Oxygen = $^{16}_{8}O$

Carbon = $^{12}_{6}C$

Sodium = $^{23}_{11}Na$

Q29. How can you determine the number of neutrons in an atom? Give one example.

Ans. The number of neutron (**N**) present in an atom can be calculated if its atomic number (**Z**) and mass number (**A**) are Known $N = A - Z$.

Example:

The number of neutrons in chlorine atom, symbolized as $^{35}_{17}C$ can be calculated as:

No. of neutrons $= 35 - 17 = 18$

Q30. Write down the symbol of copernicum and also indicate its year of discovery.

Ans. Symbol = Cn

Year of dicovery = 1996

Q31. Calculate the number of electrons. Protons and neutrons in $^{137}_{56}Ba$.

Ans. No. of electrons = 56

No. of protons = 56

No. of neutrons = 137–56

= 81

Q32. Calculate the number of neutrons, protons and electrons in one atom of uranium $^{238}_{92}U$.

Ans. No. of electrons = 92

No. of protons = 92

No. of neutrons = 238–92 = 146

Q33. Calculate the number of neutrons, protons and electrons in the following atoms: $^{195}_{78}Pt$, $^{55}_{25}Mn$, $^{127}_{53}I$.

$^{195}_{78}Pt$:

Ans. No. of electrons = 78

No. of protons = 78

No. of neutrons = 195–78 = 117

$^{55}_{25}Mn$:

No. of electrons = 25

No. of protons = 25

No. of neutrons = 55–25

= 30

$^{127}_{53}I$:

No. of electrons = 53

No. of Protons = 53

No. of newtrons = 127 – 53

= 74

Exercise

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

- **$^{195}_{78}Pt$, $^{55}_{25}Mn$, $^{127}_{53}I$**

Ans. $^{195}_{78}Pt$:

Number of electrons	78	
No. of protons	78	
No. of neutrons	195	78 117

- $^{55}_{25}Mn$:

Number of electrons	25	
No. of protons	25	
No. of neutrons	55	25 30

- $^{127}_{53}I$:

Number of electrons	53	
No. of protons	53	
No. of neutrons	127	53 74

2. Why isotopes of an element show same chemical proportion while their physical propose are different?

Ans. All the isotopes of an element show similar chemical properties due to same atomic number, while physical properties depend upon mass number.

Q34. What is an isotope? Discuss the isotopes of hydrogen and carbon with diagrams.

Ans. Isotopes: Atoms of same element having different number of neutrons are called isotopes. **OR**

Atoms of same element having same atomic number but different mass number are

called isotopes.

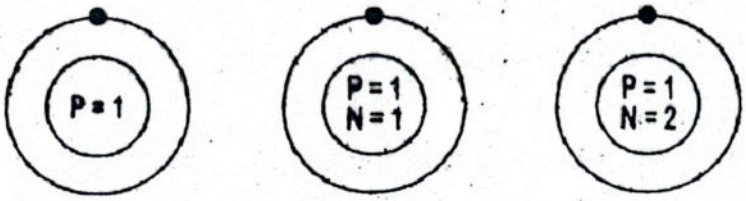
Isotopes of Hydrogen: Hydrogen has three isotopes.

Protium = $^{1}_{1}H$

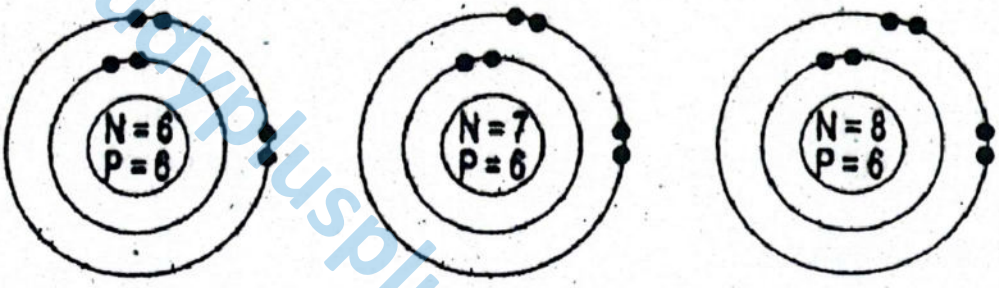
Deuterium = $^{2}_{1}H$

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

Isotopes of Hydrogen Atom $^{1}_{1}H$, $^{2}_{1}H$, $^{3}_{1}H$



Isotopes of Carbon Atom $^{12}_{6}C$, $^{13}_{6}C$, $^{14}_{6}C$.



Q35. Which isotopes of hydrogen does not have neutrons?

Ans. The isotope, protium $^{1}_{1}H$ does not have a neutron.

Q36. Why isotopes of an element show same chemical properties while their physical properties are different?

Ans. The isotopes of an element have same chemical properties because they have same atomic numbers while different physical properties because they have different mass number.

Q37. What is meant by radioactive isotopes? Give one example.

Ans. Radioactive isotopes: The isotope number can emit energy in the form of radiations are called radioactive isotopes.

Example : Tritium is the radioactive isotope of hydrogen.

Q38. What is meant by radioactive decay? Give examples.

Ans. Radioactive decay: When a radioactive element emits radiation, it is transformed into another chemical element. This process is called radioactive decay. This new element may be stable or may be unstable or may be radioactive so that it also emits radiation.

Example of radioactive decay:

$^{238}_{92}U \longrightarrow {}^{234}_{90}Th + \text{energy}$

(Uranium) (Thorium)

$^{234}_{90}$ Thorium is unstable and further disintegrates to give $^{231}_{91}$ Pa (Protactinium)

$^{234}_{90}Th \longrightarrow {}^{231}_{91}Pa + \text{energy}$

(Thorium) (Protactinium)

$^{210}_{83}Bi \longrightarrow {}^{206}_{81}Tl + \text{energy}$

(Bismuth) (Thallium)

Q39. How much atoms of our body are replaced every year?

Ans. Energy year, our body replaces about 98% of its atoms.

Q40. Write down the applications (uses) of radioactive isotopes.

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

Q41. What is radiocarbon dating?

Ans. Radiocarbon dating: Radiocarbon dating is a method for finding out the age of an historical object containing organic material with the help of radioactive isotope of carbon $^{14}_{6}C$. 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.

Q42. Write down the uses of radioactive isotopes.

Ans. Uses: 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. In medicine they are used to diagnose and treat many medical conditions and diseases, including cancer and thyroid disorders.

Q43. Discuss the ionization of atoms by a radioactive source.

Ans. Ionization of atoms by a radioactive source: The radiation emitted from a radioactive source causes ionization of atoms.

Example: Heat or light energy coming from the sum or a radioactive element can remove electron or electrons from the atom.

The ionizing radiation should have enough energy to remove the tightly bound electron from the orbit of an atom.

$$Na \xrightarrow{\text{Energy}} \underset{\text{Cation}}{Na^+} + e^-$$

The electron will be lost only when there is present another atom which can accept it.

$C\ell + 1\bar{e} \longrightarrow C\ell^- + \text{energy}$

Q44. What is meant by relative atomic mass?

Ans. Relative atomic mass: The relative atomic mass of an element is defined as the mass of an atom of that element relative to the mass of light isotope of carbon taken as 12 e.g., The mass of one atom of hydrogen - I is 1.007 amu

Q45. Define amu. Write down the relationship between amu and kg.

Ans. Atomic mass unit (amu): The unit used for relative atomic masses is called atomic mass unit. It is represented by amu.

It is defined as one-twelfth ($^1/_{12}$ th) , the mass of an atom of carbon-12.

Relationship:

$1\text{amu} = 1.67377 \times 10^{-27}\ \text{kg}$

(or) $1\text{amu} = 1.67377 \times 10^{-24}\ \text{g}$

Q46. What are the relative isotope mass and isotopic abundance? Write down their importance.

Ans. Relative atomic mass: An element usually consists of a few different isotopes with different mass numbers. These mass numbers are called relative isotopic masses.

Isotopic abundance: Each isotope will also have its own naturally occurring abundance which is called isotopic abundance.

Importance of relative isotopic mass and isotopic abundance: The relative atomic mass of an element can be calculated by using relative isotopic masses and isotopic abundance.

Q47. The element krypton (Kr) has five isotopes. Their relative isotopic masses and isotopic abundance are shown in the following Table.

Ans.

Relative Isotopic Mass	Isotopic Abundance
80	2.0%
82	12.0%
83	12.0%
84	57.0%
85	17.0%

Calculate the relative atomic mass of krypton

$$= \frac{80 \times 2.0 + 82 \times 12.0 + 83 \times 12.0 + 84 \times 57.0 + 85 \times 17.0}{100} = 83.7$$

Q48. Calculate the relative atomic mass of light isotope of chlorine. The isotopic abundance of $^{37}C\ell$ is 24.23% and light isotope of chlorine is 75.77% while relative atomic mass of chlorine is 35.45

Ans. $35.45 = \frac{(C\ell \times 75.77) + (37 \times 24.23)}{100}$

$$3545 = Cl \times 75.77 + 37 \times 24.23$$

$$3545 = Cl\ 75.77 + 896.51$$

$$3545 - 896.51 = Cl \times 75.77$$

$$Cl = \frac{2648.49}{75.77}$$

$$Cl = 34.95.$$

Relative atomic mass of light isotope of chlorine is 34.95.

Q49. Calculate the relative atomic mass of lead (Pb). Isotopic abundances of isotopes are 2.0; 24.0, 22.0, 52.0 respectively.

^{204}Pb ^{206}Pb ^{207}Pb ^{208}Pb

Ans. $$= \frac{(204 \times 2.0) + (206 \times 24.0) + (207 \times 22.0) + (208 \times 52.0)}{100}$$

$$= \frac{20722}{100} = 207.22$$

Exercise

1. Why does a radioactive isotope emit radiation?

Ans. Radioactive isotopes emit radiation because they have unstable nuclei.

2. Give an example of a radioactive isotope which disintegrates to give a stable atom.

Ans. A radioactive isotope that disintegrates to give a stable atoms is Uranium 238.

3. How would you compare the masses of the atoms of Mg and Cl?

Ans.

Magnesium	Chlorine
The relative atomic mass of Magnesium is 24.31 amu.	The relative atomic mass of chlorine is 35.45 amu.

The atom of chlorine is heavier than magnesium.

4. Calculate the relative atomic mass of Lead (Pb). Isotopic abundances of isotopes are 2.0, 22.0, 52.0 respectively.

^{204}Pb ^{206}Pb ^{207}Pb ^{208}Pb

Ans.

Relative atomic mass	Isotopic abundances
^{204}Pb	2.0%
^{206}Pb	24.0%
^{207}Pb	22.0%
^{208}Pb	52.0%

Relative atomic mass of Pb $$= \frac{(204 \times 2.0) + (206 + 24.0) + (207 \times 22.0) + (208 \times 52.0)}{100}$$

$$= \frac{20722}{100}$$

$$= 207.22$$

Relative atomic mass of Pb = 207.22

1. What do you know about radioactive decay? Explain with examples.

Ans. When a radioactive element emits radiation it is transformed into another chemical element. This process is called radioactive decay.

This new element may be stable or may be radioactive so that it also exits radiation.

Example of radioactive decay:

$^{238}_{92}U \longrightarrow {}^{234}_{90}Th$ + energy

(Uranium) (Thorium)

$^{234}_{90}$ Thorium is unstable and further disintegrates to give $^{231}_{91}Pa$ (Protactinium)

$^{234}_{90}Th \longrightarrow {}^{231}_{91}Pa$ + energy

(Thorium) (Protactinium)

$^{210}_{83}Bi \longrightarrow {}^{206}_{81}Tl$ + energy

(Bismuth) (Thallium)

2. Briefly explain the radiocarbon dating.

Ans. Radiocarbon dating: Radiocarbon dating is a method for finding out the age of an historical object containing organic material with the help of radioactive isotope of carbon $^{14}_{6}C$. 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.

3. Write down the medicinal value of radioactive isotope.

Ans. Medicinal value of radioactive isotopes: 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. In medicine, they are used to diagnose and treat many medical conditions and diseases, including cancer and thyroid disorders.

4. Calculate the relative atomic mass of lead (Pb). Isotopic abundances of isotopes are 2.0, 24.0, 22.0, 52.0 respectively ^{204}Pb ^{206}Pb ^{207}PB ^{208}Pb

Ans.

Relative isotopic mass	Isotopic Abundance
204	2.0%
206	24.0%
207	22.0%
208	52.0%

Relative atomic mass of Lead (Pb)

$$= \frac{(204\times 2.0)+(206\times 24.0)+(207\times 22.0)+(208\times 52.0)}{100}$$

$$= \frac{20727}{100} = 207.22$$

Result: Relative atomic mass of lead (Pb) = 207.22

5. Calculate the number of neutrons, protons and electrons in the following atoms. $^{195}_{78}Pt$, $^{55}_{25}Mn$, $^{127}_{53}I$

Ans. $^{195}_{78}Pt$:

No. of electrons = 78
No. of protons = 78
No. of neutrons = 195 – 78 = 117

$^{55}_{25}Mn$:

No. of electrons = 25
No. of Protons = 25
No. of neutrons = 55 – 25 = 30

$^{127}_{53}I$:

No. of electrons = 53
No. of Protons = 53
No. of Neutrons = 127 – 53 = 74

6. Write down the properties of cathode rays.

Ans. Properties of Cathode Rays:

Cathode rays have following properties:

1. These rays travel in a straight lines perpendicular to the cathode surface.
2. They can cast a sharp shadow of an opaque object if placed in their path.
3. They are deflected towards positive plate in an electric field showing that they are negatively charged.
4. They raise temperature of the body on which they fall.
5. J.I. Thomson discovered the charge / mass (e/m) ratio of cathode rays.
6. They produced light when they hit the sides of the discharge tube.
7. It was found that the same type of rays were emitted no matter which gas and which cathode was used in the discharge tube.

Additional MCQs

2.1 Structure of Atom

1. John Dalton put forward his atomic theory in:

(a) 1803 (b) 1886 (c) 1897 (d) 1913

2. How much mass of an atom is concentrated in nucleus?

(a) 10% (b) 50% (c) 99.99% (d) 9.99%

3. **The electrons are:**
   (a) Negatively charged (b) Positively charged
   (c) Neutral (d) Both a and b
4. **The protons are:**
   (a) Neutral (b) Positively charged
   (c) Negatively charged (d) Both "c" and "a".
5. **Neutron was discovered in:**
   (a) 1933 (b) 1833 (c) 1733 (d) 1633
6. **Which one of the following is a neutral particle?**
   (a) Electron (b) Proton (c) Neutron (d) Nucleus
7. **The cathode rays are:**
   (a) Positively charged (b) Negatively charged
   (c) Neutral (d) Both "a" and "b"
8. **The circular path at which electrons revolve around the nucleus is called:**
   (a) orbit (b) nucleus (c) central path (d) none of these

2.2 Atomic Number and Mass Number
2.3 Isotopes and their Masses

9. **The electrons, protons and neutrons are known as:**
   (a) Positively charged particles (b) Negatively charged particles
   (c) Sub-atomic particles of an atom (d) Macroscopic particles of an atom
10. **The number of protons present in the nucleus of an atom is called its:**
   (a) Atomic number (b) Mass number (c) Nucleon number (d) Both b and c
11. **Sum of the neutrons and protons that are present in an atom is called its:**
   (a) Atomic number (b) Nucleon number (c) Proton number (d) Both a and c
12. **Atom as a whole is:**
   (a) Positively charged (b) Negatively charged
   (c) Neutral (d) None of these
13. **Atoms of same element having different number of neutrons are called:**
   (a) Ions (b) Compound ions (c) Allotropes (d) Isotopes
14. **Isotopes having same number of:**
   (a) Neutrons (b) Neutrons and protons
   (c) Electrons and neutrons (d) Protons and neutrons
15. **All the Isotopes of an element having different:**
   (a) Chemical properties (b) Number of protons
   (c) Physical properties (d) Number of electrons
16. **The isotopes which and emit radiations by themselves are called:**
   (a) Radioactive isotope (b) Positive isotopes
   (c) Allotropes (d) None of these
17. **The mass of an atom of that element relative to the mass of light isotope of carbon taken as 12 is called:**
   (a) Relative atomic mass (b) Molecular mass

(c) Consecutive mass (d) None of these

18. **How many electrons are accommodated in 2nd shell?**
(a) 2 (b) 8 (c) 18 (d) 32

ANSWERS:

1.	(a)	2.	(c)	3.	(a)	4.	(b)	5.	(a)	6.	(c)	7.	(b)
8.	(a)	9.	(c)	10.	(a)	11.	(b)	12.	(c)	13.	(d)	14.	(d)
15.	(c)	16.	(a)	17.	(b)	18.	(d)						

Conceptual MCQs

1. **The presence of positively charged particles in an atom was first observed by:**
(a) Bohr (b) E. Goldstein (c) Rutherford (d) None of these

2. **Which one of the following is a lustrous element?**
(a) Sulphur (b) Aluminium (c) Oxygen (d) Both a and c

3. **How many times the protons is heaver than electron?**
(a) 1836 (b) 1736 (c) 1636 (d) 1536

4. **Which one of the following is a neutral particle?**
(a) Electron (b) Protons (c) Neutron (d) None of these

5. **Which sub-atomic particle has a charge equal to -1.6022×10^{-19} C?**
(a) Proton (b) Electron (c) Neutron (d) Nucleus

6. **The maximum number of electron which can be accommodated in s-sub-shell is:**
(a) 6 (b) 10 (c) 2 (d) 14

7. **The sum of the protons and neutrons that are present in the nucleus of an atom is known as:**
(a) Nucleon number (b) Proton number
(c) Atomic number (d) None of these

8. **The maximum number of electrons which can be accommodated in "d" sub-shell is:**
(a) 2 (b) 6 (c) 10 (d) 14

9. **The number of neutrons in $^{23}_{11}Na$ is:**
(a) 11 (b) 23 (c) 12 (d) 34

10. **Deuterium is an isotope of:**
(a) Carbon (b) Hydrogen (c) Oxygen (d) Lead

11. **Every year, our body replaces about how much of its atom?**
(a) 50% (b) 30% (c) 98% (d) 60%

12. **The relative atomic masses of elements are expressed in units:**
(a) Atomic mass unit (amu) (b) Kilogram (Kg)
(c) Grams (g) (d) Milligram (mg)

13. **How many electrons can be accommodated in-f-sub-shell?**
(a) 2 (b) 6 (c) 10 (d) 14

14. **Which one of the following atom does not have neutrons?**
(a) Protium (b) Deuterium (c) Tritium (d) Carbon

15. **The number of neutrons in $^{238}_{92}U$ is:**

(a) 92 (b) 238 (c) 146 (d) 138

16. **Which particle has charge equal to $9.10^9 \times 10^{-31}$ kg?**

(a) Neutron (b) Proton (c) Electron (d) Nucleus

17. **Which particle has charge equal to 0?**

(a) Neutrons (b) Protons (c) Electrons (d) Both a and b

18. **The maximum number of electnens which can be accumulate ate in L-shell:**

(a) 2 (b) 8 (c) 18 (d) 14

19. **Which one of the following is correct for isotopes?**

(a) Having same number of neutrons (b) Having same physical properties
(c) Having same chemical properties
(d) Having same physical and chemical properties

20. **Which isotope of carbon has 7 neutrons?**

(a) $^{12}_{6}C$ (b) $^{13}_{6}C$ (c) $^{11}_{6}C$ (d) Both a and b

ANSWERS:

1.	(b)	2.	(b)	3.	(a)	4.	(c)	5.	(b)	6.	(c)	7.	(a)
8.	(c)	9.	(c)	10.	(b)	11.	(c)	12.	(a)	13.	(d)	14.	(a)
15.	(c)	16.	(b)	17.	(a)	18.	(b)	19.	(c)	20.	(b)		

Additional Short Questions

2.1 Structure of Atom

1. What are cathode rays?

Ans. Cathode rays: The rays which originate from cathode and move towards the anode are called cathode rays.

2. What are shells (orbits)?

Ans. The circular path at which electrons revolve around the nucleus is called shell or energy level.

3. Define electronic configuration.

Ans. Electronic configuration: The arrangement of electrons around the nucleus is called electronic configuration.

4. Write down the formula for electronic configuration.

Ans. Formula for electronic configuration = $2n^2$ Where "n" shows the number for orbit.

5. How many electrons can be accommodated in first shell? According to formula $2n^2$?

Ans. Number of electrons in first shell = $2n^2 = 2(1)^2 = 2$.

2.2 Atomic number and Mass Number

2.3 Isotopes and their Masses

6. What is meant by proton number?

Ans. The number of protons present in the nucleus of an atom is called proton number. For example, proton number of carbon is 6.

7. Define nucleon number.

Ans. **Nucleon number:** The sum of protons and neutrons that are present in the nucleus of an atom is called nuclear number e.g. nucleon number of carbon is 12.

8. Calculate the number of electrons protons and neutrons in $^{40}_{20}Ca$.

Ans. No. of electrons = 20
No. of protons = 20
No. of neutrons = 40–20 = 20

9. What are isotopes? How many isotopes of carbon are there?

Ans. **Isotopes:** Atoms of same element having different number of neutrons are called isotopes.

Isotopes of carbon: Carbon has three isotopes $^{12}_{6}C$, $^{13}_{6}C$, $^{14}_{6}C$.

10. Write down any two uses of radioactive isotopes.

Ans. Radioactive isotopes are useful in medicinal imaging. They are used to produced nuclear power.

11. What is the relationship between amu and kg?

Ans. 1amu = 1.67377×10^{-27} kg.

Conceptual Short Questions

1. How the elements are made up of?

Ans. The elements are made up of atoms.

2. Why the elements are different from one another in their properties?

Ans. The difference in the properties of elements is due to the difference in the properties of their constituents atom.

3. Who studied the properties of cathode rays by passing through them oppositely charge plates?

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

4. What is the comparison of size of nucleus and size of atom?

Ans. The nucleus is less than one hundred thousandth (1/100, 000) of the size of the atoms.

5. Why the atom as a whole in electrically neutral?

Ans. The atoms as a whole are electrically neutral because they have same number of electrons and protons.

6. What do you know about copernicium?

Ans. Copernicium is a synthetic element. Its symbol is **Cn.** It was discovered in 1996.

This metal turns into gas at room temperature.

7. **How many times cesium is bigger than helium?**

Ans. Cesium is approximately nine times bigger than helium.

8. **Write down the properties of gallium.**

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.

9. **Why radioactive isotopes emit radiation?**

Ans. The radioactive isotopes emit radiations because they have unstable nuclei. They have unstable combination of protons and neutrons.

10. **Write down the number of isotopes of krypton (kr).**

Ans. The element krypton has five isotopes.

Key Points

1. An English chemist, John Dalton provided the evidence for the existence of atoms.
2. Discharge tube experiments showed that atoms are no longer smallest particles of matter. Rather they are made up of still smaller particles called electron and proton. Neutron was discovered separately.
3. Electrons, protons and neutrons are shown to be present in all the elements irrespective of the fact that the elements behave very differently. Different elements, however, contain different number of these particles.
4. Lord Rutherford discovered that all atoms have a central part which he named as nucleus. The protons and neutrons are present in this nucleus while the electrons are revolving around the nucleus.
5. An atom being electrically neutral contains the same number of electrons and protons.
6. According to Bohr's atomic model, the electron revolves around the nucleus in definite circular paths called orbits or shells. As long as electron revolves in an orbit its energy remains fixed. An electron will have more energy if it is located away from the nucleus.
7. The number of protons present in the nucleus of an element is called the atomic number of that element.
8. The total number of protons and neutrons present in the nucleus of an element in called its mass number.
9. Isotopes are the atoms of the same element which have the same number of protons but different number of neutrons.
10. Isotopes of an element have same chemical properties but they differ in their physical properties.
11. Isotopes of an element may be stable or radioactive. Radioactive isotopes have many useful applications in medicine.
12. Radioactive isotopes have unstable nuclei and they throw out radiation.
13. Relative atomic mass of an element can be calculated from the relative isotopic masses of this element and their isotopic abundances.

1 Tick (✓) the Correct answer.

(i) How many electrons can be accommodated at the most in the third shell of the elements?

(a) 8 (b) 18 (c) 10 (d) 32

(ii) 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.

(iii) 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.

(iv) Which particle is present in different number in the isotopes?

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

(v) In which isotope of oxygen there are the equal number of protons, electrons and neutrons?

(a) ^{17}O (b) ^{16}O (c) ^{18}O (d) Non of these

(vi) 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 respectively.

(a) 14.0210 (b) 14.0021 (c) 14.2100 (d) 14.1200

(vii) How is radiocarbon dating useful for archeologists?

(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.

(viii) What does keep 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.

(ix) 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

(x) **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%

ANSWERS:

i. (b) ii. (d) iii. (c) iv. (b) v. (a) vi. (a) vii. (a) viii. (a) ix. (b) x. (b)

② Questions for Short Answers

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

Ans. It is said 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 in nucleus.

ii. **Why are elements different from one another?**

Ans. The elements are different from one another because the atoms of one element differ from the atoms of other element because they contain different number of fundamental particles.

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

Ans. No. of neutrons = 210 – 83 = 127 ,

iv. **Why is tritium ($^{3}_{1}H$) a radioactive element?**

Ans. The isotope which emits energy is called radioactive isotope. Tritium is radioactive isotope because it emits radiations.

v. **How can an atom absorb and envolve energy?**

Ans. Atoms absorb energy when electrons move to higher energy levels (excited state) after gaining energy. They release energy when electrons retum to lower energy levels (ground state). This process is observed as the emission or absorption of light or other forms of energy.

③ Constructed Response Questions

i. **Why does the energy of electron increase as we move from first shell to second shell?**

Ans. Electrons present in each shell have fixed energy. The energy of electron increases as we move from first to second shell because the second shell is farther away from the nucleus as first shell.

ii. **Why is it needed to lower the pressure of the gas inside the discharge tube?**

Ans. It is needed to lower the pressure inside the discharge because current cannot pass through the gases at ordinary pressure.

iii. **What is the classical concept of an electron? How has this concept changed with time?**

Ans. The classical concept of an electron, based on the early atomic models such as J.J.Thomson's and Bohr,s models explain electrons as small particles orbiting the nucleus in fixed circular paths (orbits) similar to planets orbiting the Sun. However,

with the development of quantum mechanics, this concept changes. The modern quantum mechanical model describes electron as exciting in regions called orbital, where there is a high probability of finding them. Unlike fixed paths, orbitals represent three dimensional regions around the nucleus and electrons exhibit both particle like and wave- like behaviors. This understanding was made possible by advancements in the Schrodinger equation and Heisenberg uncertainty principle.

iv. Why the nuclei of the radioactive elements are unstable?

Ans. The nuclei of radioactive elements are unstable be cause of an in imbalance of forces between the particles in the nucleus.

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. Scientists observed that the cathode rays produced in a discharge tube always exhibited the same properties, regardless of the gas used in the tube. These rays were found to consist of negatively charged particles (electrons) with a fixed change-to-mass ratio, independent of the type of atom or element present.

Similarly, the positive rays (protons) generated in these experiments had consistent properties across different gases. This uniformity demonstrated that electrons and protons are fundamental components of all atoms and their properties do not vary from one element to another.

④ Descriptive Questions

i. Explain the structure of hydrogen atom.

Ans. A hydrogen atom is the simplest atom, consisting of a single proton in the nucleus and one electron revolving around it. The nucleus, which contains the proton, is positively charged, while the electron is negatively charged. The electron occupies a specific energy level (or shell) around the nucleus. In the modern quantum mechanical model, the electron is described as existing in a mass orbital around the nucleus, where it is most likely to be found. Since hydrogen has no neutrons, its mass is almost entirely due to the proton.

ii. How does the theory of atomic structure explain the ionization of atoms by a radioactive isotope?

Ans. *Ionization* occurs when an atom loses or gains an electron' resulting in a charged particle called an ion. Radioactive isotopes emit high- energy particle or radiation (alpha, beta or gamma ays) that can knock electrons out of atoms. For example, beta particles emitted by radioactive isotopes have enough energy to remove electrons from nearby atoms, creating ions. This process is the basis for many applications of radioactive isotopes such as radiation therapy and smoke detectors.

iii. What is radioactivity? Explain any three applications of radioactive isotopes.

Ans. Radioactivity is the spontaneous emission of particles or energy from the unstable nucleus of an atom. This occurs as the nucleus seeks to become more stable.

Applications of Radioactive isotopes: Radioactive isotopes are useful in medical imaging. Doctors use them to diagnose the disease by injecting the patient with a small amount of radioactive fluid. Technetium-99m is used for diagnostic imaging

across human organs like brain, lungs, etc. Doctors use a special camera to watch how the radioactive fluid moves.

iv. Find out the relative atomic mass of mercury from the following data.

Isotope		Relative Abundance	Isotope		Relative Abundance
^{196}Hg	=	0.0146%	^{199}Hg	=	16.34%
^{198}Hg	=	10.02%	^{200}Hg	=	23.13%
^{201}Hg	=	13.22%	^{202}Hg	=	29.80%
^{204}Hg	=	6.85%			

Ans. To calculate the relative atomic mass, use the formulas

Ar = (Isotope mass × Relative abundance fraction) Substitute the given values.

Ar = (199 × 0.00146) + (198 × 0.1002) + (200 × 0.1322) + (201 × 0.0685) +(202 × 0.1634) + (204 × 0.2313) + (206 × 0.298)

After performing the calculations, the final relative atomic mass is obtained. This process demonstrates how isotopes contribute to the average atomic mass of an element.

⑤ Investigative Questions

i. How can scientists synthesize elements in the laboaratory?

Ans. Scientists synthesize new elements by bombarding the nuclei of existing elements with high - speed particles such as protons, neutrons, or heavier ions. This process often takes place in particles accelerators where the nuclei are forced to collide with enough energy to fuse and form a new element. For example, synthetic elements like Uranium - 235 and Tranuranium elements like americium and einsteinium were created in this way. These processes require precise conditions and advanced technology.

ii. A system just like our solar system exists in an atom. Comment on the statement.

Ans. The early atomic model proposed by Niels Bohr compared the atom to a miniature solar system, with electrons revolving around the nucleus in circular orbits, similar to how planets orbit the sun. While this analogy helped visualize atomic structures modern quantum mechanics has shown that electrons do not follow fixed orbits. Which are shaped by their energy levels and interactions. Unlike planets, electrons also exhibit wave - particle duality, a concept that cannot be explained using the solar system analogy.