



## CHAPTER 5 STRUCTURE OF THE ATOM

### SOLUTIONS

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**1. Who proposed the atomic theory?**

**Ans:** John Dalton proposed the atomic theory

**2. From which electrode do the cathode rays originate?**

**Ans:** The cathode rays originate from the cathode

**3. What happens to cathode rays when they are subjected to an electric field?**

**Ans:** The cathode rays bent when they are subjected to an electric field.

**4. What is the charge of an electron?**

**Ans:** The charge of an electron is -1.

**5. Where is the mass of an atom concentrated?**

**Ans:** The mass of an atom is concentrated at the Nucleus.

**6. What are the particles present in the nucleus of an atom?**

**Ans:** Proton, Neutron and Electron are the particles present in the nucleus of an atom.

**7. Where are the electrons in an atom found?**

**Ans:** Electrons are found in shells or orbitals that surround the nucleus of an atom.

**8. Which atom contains only two fundamental particles?**

**Ans:** Protium (an isotope of hydrogen) contains only two fundamental particles.

**9. What led Rutherford to discover the existence of nucleus?**

**Ans:** Since electrons have negligible mass, the entire mass of the atom was regarded as the mass of protons in the nucleus. This means that the nucleus must contain protons equal to the mass of the atom. But the no. of protons is equal to the atomic number. This means that atomic mass should be equal to the atomic number. However, for all atoms except hydrogen, the atomic mass is more than the atomic number. This led Rutherford to discover the existence of nucleus.



**10. Define (a) atomic number and (b) mass number**

**Ans:**

(a) Atomic number: Atomic number is the number of protons in the nucleus of an atom, which is characteristic of chemical properties of an element and determines its place in the periodic table.

(b) Mass number: Mass number is the total number of protons and neutrons in a nucleus.

**11. What are isotopes? Give one example.**

**Ans:** Those elements that have the same atomic number but different mass number are referred to as isotopes.

**Eg:** The isotopes of hydrogen are protium (has one proton and no neutrons), deuterium (has one proton and one neutron) and tritium (has one proton and two neutrons).

**12. What are cathode rays and how do they differ from positive rays?**

**Ans:** Cathode rays are a beam of negatively charged electrons travelling from the negative end of an electrode to the positive end within a vacuum, across a potential difference between the electrodes.

**Cathode rays:**

1. They are stream of negatively charge electrons.
2. Cathode rays **deflect towards the positive plate of an electric field.**

**Positive rays (Anode rays):**

1. They have **positively charges material particles.**
2. Anode rays **deflect towards the negative plate of an electric field.**



13. Give experimental evidence to show that:

- (i) The entire mass of an atom is practically concentrated in the nucleus.
- (ii) The nucleus of an atom is positively charged.

Ans:

- (i) Alpha particles are positively charged particles. In Rutherford's gold foil experiment, some of the alpha particles are deflected in certain angles and very few of them suffered large deflections. This means that there is a heavy positively charged mass concentrated and occupies very small volume at the centre of the atom called nucleus.

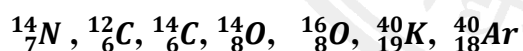
This evidence shows that the entire mass of an atom is practically concentrated at the nucleus.

- (ii) We know that equal charge repel each other. The positively charged alpha particles suffered deflection and even bouncing back after meeting the small mass concentrated at the nucleus due to the force of repulsion shows that the nucleus of an atom is positively charged.

14. Derive a relationship between atomic number, mass number and number of neutrons in an atom.

Ans: Mass Number = Atomic Number + Number of neutrons.

15. How many protons, electrons and neutrons are there in the following atoms?



Which of these are (a) isotopes, and (b) isobars?

Ans:

	No. of protons	No. of electrons	No. of neutrons
${}^{14}_7\text{N}$	7	7	7
${}^{12}_6\text{C}$	6	6	6
${}^{14}_6\text{C}$	6	6	8
${}^{14}_8\text{O}$	8	8	6
${}^{16}_8\text{O}$	8	8	8
${}^{40}_{19}\text{K}$	19	19	21
${}^{40}_{18}\text{Ar}$	18	18	22



$^{12}_6\text{C}$  and  $^{14}_6\text{C}$  are isotopes.

$^{14}_8\text{O}$  and  $^{16}_8\text{O}$  are isotopes.

$^{14}_7\text{N}$ ,  $^{14}_6\text{C}$  and  $^{14}_8\text{O}$  are isobars

$^{40}_{19}\text{K}$  and  $^{40}_{18}\text{Ar}$  are isobars

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*Let us answer these:*

**1. Which subatomic particle was not present in Thomson's model of the atom?**

**Ans:** Neutron

**2. State one drawback of Rutherford's model of atom.**

**Ans:** According to electromagnetic theory, if a charged particle (electron) revolves round the positively charged nucleus, the electron would continuously lose energy and will finally fall into the nucleus. This will make atom highly unstable

**3. Why is an atom neutral inspite of the presence of charged particles in it?**

**Ans:** In an atom, the number of electrons outside the nucleus is equal to the number of positively charged particles in the nucleus. Hence the atom is neutral (no charge).

**4. How did Neils Bohr's explain the stability of the atom?**

**Ans:** According to Neils Bohr:

(i) The Electrons could revolve around the nucleus in only certain orbits or certain energy levels, each Orbit having a different radius.

The electrons which are in orbits close to the nucleus have low energy while those in orbits farther from the nucleus have higher energy.

(ii) When an electron is revolving in a particular orbit or energy level around the nucleus, the electrons does not lose energy even though it has accelerated motion around the nucleus.

Since, the electrons do not lose energy while revolving in certain permitted orbits they do not fall into the nucleus and hence the atom remains stable.

**5. What are the various letters used in Bohr's model to represent electron shells in an atom?**

**Ans:** K, L, M, N.... etc





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(ii) Mass Number =  $7 + 8 = 15$

(iii) the number of electrons = 7

(iv) the number of valence electrons = 5 {K (2), L(5)}

2. What is the general name of the elements having 8 electrons in the outermost shells of their atoms?

Ans: Noble gases or Inert gases,

3. The atomic number of an element X is 15.

(i) Write down the electronic configuration of X.

(ii) What will be the valency of X?

Ans:

(i) The electronic configuration of X(15) = 2, 8, 5

(ii) The valency of X = 3 (8-5)

4. How will you find the valency of Chlorine, potassium and sulphur?

Ans:

The electronic configuration of Chlorine (17) = 2, 8, 7

So, Valency of Chlorine is  $8 - 7 = 1$

The electronic configuration of Potassium (19) = 2, 8, 8, 1

So, Valency of Potassium is = 1

The electronic configuration of Sulphur (16) = 2, 8, 6

So, Valency of Sulphur is =  $8 - 6 = 2$

### EXERCISES

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1. Name the three subatomic particles present in an atom and compare their properties.

Ans: The three subatomic particles present in an atom are:

(i) Protons are positively charged particles. They are present inside the nucleus along with Neutrons.

(ii) Neutrons are neutral particles.

(iii) Electrons are negatively charged particles which revolve around in the round orbits around the nucleus.

2. What atom does not contain neutron?

Ans: Protium (an isotope of Hydrogen) does not contain neutron.



**3. Describe the Rutherford's model of an atom. What are its limitations?**

**Ans:** Rutherford proposed an atomic model similar to the structure of solar system. Just as in the solar system, the sun is at the centre (having the maximum mass) and the planets revolve around it, in an atom, the nucleus contains the main mass and the electrons revolve around it in orbits or shells.

Its limitations are:

- (i) According to electromagnetic theory, if a charged particle (electron) revolves round the positively charged nucleus, the electron would continuously lose energy and will finally fall into the nucleus.
- (ii) This will make atom highly unstable

**4. Describe Bohr's model of the atom.**

**Ans:** This model of atom states that:

The nucleus is situated at the centre of the atom.

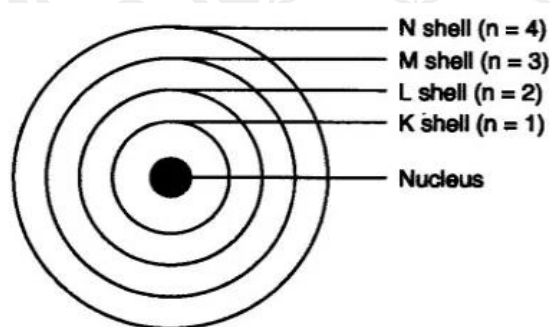
An atom consists of heavy positively charged nucleus. The whole mass of the atom is concentrated in the nucleus.

The electrons in an atom revolve around the nucleus in definite circular paths called orbits or energy level or shells are numbered as 1, 2, 3, 4 ..... etc. (from the nucleus) or alternatively these are designated as K, L, M, N, ..... shells.

Each energy level is associated with definite amount of energy.

The change in energy takes place when electron jumps from one energy level to another energy level.

To change from one orbit to another, the electron must absorb or emit a quantity of energy exactly equal to the difference in energy between the two orbits.



Bohr's model

**5. Explain with examples (i) Atomic Number (ii) Mass Number (iii) Isotopes and (iv) Isobars. Give any two uses of isotopes.**

**Ans:**

(i) **Atomic Number:** The total number of proton lying in the nucleus of any atom is called the atomic number. Atomic number is denoted by 'Z'.

**E.g.** No. of Protons present in a Sodium Atom is 11. So Atomic number of Sodium is 11

(ii) **Mass Number:** It is the sum of Number of Protons and Neutrons present in the nucleus.

**E.g.** No of proton present in Sodium Atom is 11 and No. of neutrons present in Sodium Atom is 12. So Mass No. of Sodium atom is  $11 + 12 = 23$





(iii) **Isotopes:** Those elements that have the same atomic number but a different mass number are referred to as isotopes.

**E.g.** The isotopes of hydrogen are Protium (has one proton and no neutrons), deuterium (has one proton and one neutron) and tritium (has one proton and two neutrons).

(iv) **Isobars:** Isobars are the atoms having the same mass number but a different atomic number. For example, the atomic number of carbon and nitrogen is 6 and 7 respectively. Carbon-14 an isotope of carbon has a mass number of 14 which is same as that of nitrogen and hence carbon-14 and nitrogen are isobars.

Any two uses of Isotopes are

An isotope of cobalt known as cobalt-60 is used in the treatment of Cancer.

An isotope of iodine (iodine-131) finds application in the treatment of diseases like goitre.

6. The mass number of an element is 40. It contains 19 electrons. What is the number of protons and neutrons in it? What is the atomic number of the element?

**Ans:**

No. of protons = No. of electrons = 19

No. of neutrons = Mass No – No. of electrons =  $40 - 19 = 21$

The Atomic number of the element = No of electrons = 19

7. Write the electronic configuration of potassium atom ( $Z = 19$ )

**Ans:** The electronic configuration of potassium atom ( $Z = 19$ ) = 2, 8, 8, 1

8. Explain why, sodium ion,  $\text{Na}^+$ , has completely filled K and L shells?

**Ans:** When sodium atom loses 1 electron, it becomes sodium ion  $\text{Na}^+$  which has 10 electrons. It has 2 electrons in K-shell and 8 electrons in L-shell. K-shell ( $n=1$ ) can have maximum  $2 \times 1 \times 1 = 2$  electrons and L-shell ( $n = 2$ ) can accommodate maximum  $2 \times 2 \times 2 = 8$  electrons. Therefore,  $\text{Na}^+$  has completely filled K and L- shells.

9. If both K and L shells of an atom are full, what is the total number of electrons in the atom?

**Ans:** The total number of electrons in the atom is 10.

10. If bromine atom is available in the form of two isotopes  $^{79}_{35}\text{Br}$  (49%) and  $^{81}_{35}\text{Br}$  (51%). Calculate the average atomic mass of Bromine atom.

**Ans:**

Average atomic mass of bromine

$$= (79 \times 49\%) + (81 \times 51\%)$$

$$= 79 \times \frac{49}{100} + 81 \times \frac{51}{100}$$

$$= 79 \times 0.49 + 81 \times 0.51$$

$$= 38.71 + 41.31$$

$$= 80.02 \text{ u}$$





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11. Composition of the nuclei of two atomic species x and y are as follows:

X	Y
No. of protons = 15	15
No. of neutrons = 15	16

Give the mass numbers of X and Y. What is the relation between the two species?

Ans:

The mass of X =  $15 + 15 = 30$

The mass of Y =  $15 + 16 = 31$

X and Y are Isotopes.

12. What is the relation between the valency of an element and the number of valence electrons in its atoms. Explain with examples.

Ans: Valency of the atom of an element determines the valency of an element.

In case of the metals, the valence electrons represent the valency of the metal elements (positive valency). E.g.

Element	Electronic configuration
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Li	2, 1 (valency is 1)
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Mg	2, 8, 2 (valency is 2)
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Al	2, 8, 3, (valency is 3)
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In case of the non-metal, the less number of electrons to achieve octet (8) configuration from the valence electron gives its valency. E.g.

Element	Electronic configuration
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C	2,4 ( $8-4 = 4$ i.e. valency is 4)
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P	2,8,5 ( $8-5 = 3$ i.e. valency is 3)
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O	2,6 ( $8-6 = 2$ i.e. valency is 2)
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F	2,7 ( $8-7 = 1$ i.e. valency is 1)
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In case of the noble gases or inert gases, the valency remains zero.

E.g.

H	2 (zero valency)
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Ne	2,8 (valency is zero)
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Ar	2,8,8 (valency is zero)
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In exception, hydrogen have both positive and negative valency i.e. 1 (one) and Boron which is a typical non metal has valency 3.

B	2,3 (valency is 3)
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*[Note: Boron does not obey octet rule]*



13. Complete the following table:

Atomic Number	Mass Number	Number of Protons	Number of Neutrons	Number of Electrons	Name of the Atomic Species
11	23	11	12	11	Sodium Atom
11	23	11	12	10	Sodium ion
17	35	17	18	17	Chlorine Atom
17	35	17	18	18	Chloride ion
13	27	13	14	13	Aluminum Atom

EXTRA QUESTIONS AND ANSWERS

1. Why did Rutherford select a gold foil in his alpha ray scattering experiment?

Ans. Gold is highly malleable. Hence it can be made into very thin sheets. Rutherford wanted a metal sheet which could be as thin as possible. So he selected a gold foil in his alpha ray scattering experiment.

2. State the contributions of the following scientists towards the understanding of the atomic structures.

(i) John Dalton (ii) J.J Thomson (iii) E. Gold stein (iv) Ernest Rutherford (v) James Chadwick

Ans:

- (i) John Dalton –Indivisibility of atoms
- (ii) J.J Thomson- Discovery of electron
- (iii) E. Goldstein –Discovery of the existence of protons
- (iv) Ernest Rutherford – Concept of nucleus
- (v) James Chadwick – Discovery of neutron

3. An element has a mass number 4 and atomic number 2. Write the valency of this element.

Ans: Valency is 0 (zero) as K shell is completely filled.

4. Will  $^{35}\text{Cl}$  and  $^{37}\text{Cl}$  have different valencies? Justify your answer.

Ans: They are isotopes. Isotopes have same number of electrons in them. Hence their valencies do not differ.

5. Summarize the rules for writing distribution of electrons in various shells.

Ans: The rules are:

- (i) The maximum number of electrons that can be present in a shell is  $2n^2$  where n is the orbit number. Thus  
For the first orbit ( $n=1$ ) or K shell, maximum number of electrons  $=2 \times 1^2 = 2$   
For the second orbit ( $n=2$ ) or L shell, maximum number of electrons  $=2 \times 2^2 = 8$   
For the third orbit ( $n=3$ ) or M shell, maximum number of electrons  $=2 \times 3^2 = 18$   
For the fourth orbit ( $n=4$ ) or N shell, maximum number of electrons  $=2 \times 4^2 = 32$  and so on



- (ii) The maximum number of electrons that can be accommodated in the outermost orbit is 8 and the next to outermost known as penultimate orbit cannot have more than 18 electrons.
- (iii) It is not necessary for an orbit to be completed before the next orbit starts filling. In fact, a new orbit begins when the previous orbit gets 8 electrons.

### EXTRA QUESTIONS FROM TEXTBOOK

**1. What are the characteristics of cathode rays?**

**Ans:** The cathode rays, like light travelled in a straight line, cast shadows of obstacles but unlike light, could be bent by electric and magnetic fields. They consist of charged particles.

**2. What constitute cathode rays and anode rays?**

**Ans:** Cathode rays consist of negatively charged particles. These rays are the stream of electrons.

Anode rays consist of positively particles. These rays are the stream of protons.

**3. What are the explanations made by Ernest Rutherford after the bombardment with a beam of alpha particles in a thin gold foil?**

**Ans:**

- (i) Atoms of the gold are actually touch to one another (closely packed).
- (ii) Since most of the  $\alpha$ -particles pass through the gold foil un-deflected, there must be a very large empty space within the atom.
- (iii) Alpha particles are positively charged and have considerable mass. Since few of the  $\alpha$ -particles are deflected to certain angles, it implies that there is a heavy positively charged mass present in the atom which is known as nucleus.
- (iv) The strong deflections, bouncing or even bouncing back of  $\alpha$ -particles from the foil were explained to be the result of a direct collision with the positively charged nucleus of the atom.
- (v) In an atom there are just enough electrons outside the positive nucleus to provide a balance of positive and negative charges.

**4. What are nucleons?**

**Ans:** The total number of protons and neutrons present in the nucleus are collectively known as nucleons.

**5. Define mass number.**

**Ans:** The total number of protons and neutrons contained in an atom is known as mass number.

**6. What are isotopes? What is the main cause of the isotopes of an element?**

**Ans:** The atoms of the same element having the same atomic number but different mass numbers are called isotopes of the element.

The main cause of isotopes (isotopic forms) of an element is due to the different in the number of neutrons present in the nucleus of the atom having the same atomic number.



7. Give the name of the instrument which help in the discovered of isotopes of an element.

Ans: Mass Spectrometer.

8. Why the chemical properties of isotopes are similar?

Ans: Because, all the isotopes have the same number of protons and neutrons.

9. Write three uses of isotopes in various fields.

Ans:

(i) An isotope of Uranium-235 is use as fuel in nuclear reactors.

(ii) An isotope of Cobalt known as Cobalt-60 is used in the treatment of cancer.

(iii) An isotope of iodine known as iodine-131 finds application in the treatment of diseases like goitre.

10. Write the names of three isotopes of hydrogen with their representative symbols.

Ans: (i) Protium ( ${}^1_1H$ ); (ii) Deuterium ( ${}^2_1D$ ) ( ${}^2_1H$ ); (iii) Tritium ( ${}^3_1T$ ) ( ${}^3_1H$ ) ( ${}^3_1H$ ).

11. What are isobars? Give an example.

Ans: Atoms of different elements having same mass number but different atomic numbers are known as isobars.

E.g. (i)  ${}^{14}_6C$  and  ${}^{14}_7N$  (ii)  ${}^{40}_{18}Ar$ ,  ${}^{40}_{19}K$ ,  ${}^{40}_{20}Ca$

12. What is the assumption of J. J. Thomson about an atom?

Ans: Thomson assumed that an atom is a uniform sphere of positive charges with electrons embedded in it.

13. Why is Thomson's Model of atom also known as "raisin pudding" model?

Ans: At Thomson's time, no neutron was discovered and it was assumed that electrons are embedded in the sphere of positive charges. Hence, the model of atom is also known as "raisin pudding" model.

14. What is penultimate orbit? How many electrons can be accommodated at this orbit?

Ans: The next to the outermost orbit is known as penultimate orbit. 18 electrons can be accommodated at this penultimate orbit.

15. Define valence electrons.

Ans: The total electrons present in the outermost shell of an atom are known as valence electrons.

16. Why does only the valence electron of an atom take part in chemical combination?

Ans: Because they have more energy than the inner electrons of the atom.

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