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TOPIC-1

Structure of an Atom, Different models of Atom, Electron distribution and Valency

Revision Notes

- We know that atoms and molecules are the fundamental building blocks of matter. The existence of different kinds of matter is due to different atoms constituting them. There are certain models that have been proposed to explain how these particles are arranged with in the atom.
- A major challenge before the scientists at the end of the 19^{th} century was to reveal the structure of the atom as well as to explain its important properties.
- **Charged particles in matter**

  The particles that carry an electric charge are called charged particles. They become electrically charged on rubbing two objects together.

  It means that some charged particles are present with in the atom. Such particles are electrons and protons.
- **Summary of characteristics of electrons, protons and neutrons**

Characteristics	Electron	Proton	Neutron
Symbol	e	p	n
Relative charge	–1	+1	0
Nature	Negatively charged	Positively charged	Neutral
Discovered by	J. J. Thomson	E. Goldstein	James Chadwick
Mass	1/1837 times mass of hydrogen atom	1 a.m.u (same as that of hydrogen)	Mass is nearly equal to that of proton

- **Structure of an Atom**

  Dalton's atomic theory suggested that the atom was indivisible and indestructible. But the discovery of two fundamental particles (electrons and protons) inside the atom led to the failure of this aspect of Dalton's atomic theory. It was necessary to know how electrons and protons are arranged within an atom. Many theories and models were presented to explain the atomic model. J. J. Thomson was the first who proposed a model for the structure of an atom.

- **Thomson's model of an Atom**

  (i) An atom is a uniform sphere of positive charges (due to presence of protons) as well as negative charges (due to the presence of electrons) which are embedded in it. This model is often called the "Plum Pudding or Water Melon Model".

  (ii) An atom, as a whole is electrically neutral because the negative and postive charges are equal in magnitude.

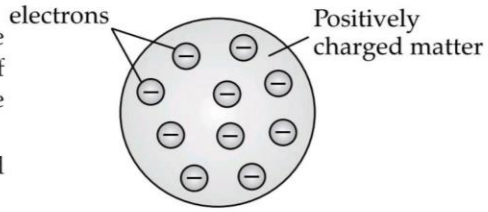


Fig 3.1 Thomson's model of a atom.

- **Limitatons of Thomson's model of atom**

The model failed to explain how protons and electrons could be arranged in an atom so close to each other.

- **Rutherford's model of an Atom**

Ernest Rutherford was interested in knowing how the electrons are arranged within an atom.

α-Particles are charged particles having two units of positive charge and four units of mass i.e. they are doubly charged Helium ions (He^{2+})

- **Observations predicted from α-particle scattering experiment by Rutherford based on Thomson's model of atom**

  (i) Rutherford expected that if the model proposed earlier by J. J. Thomson, according to which there is uniform distribution of positive and negative charge, was correct then α-particles striking the gold atoms would be uniformly deflected which was not the case.

  (ii) Since the α-particles were much heavier than the protons, he did not expect to see large deflections.

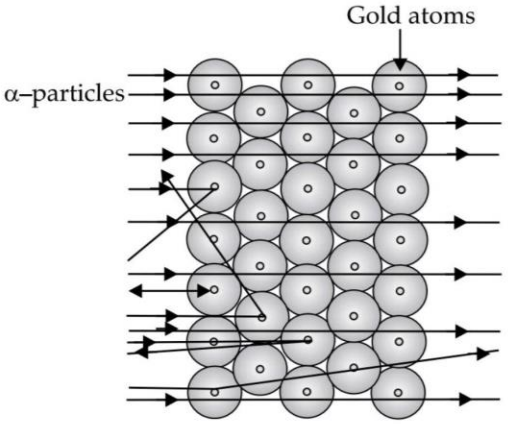


Fig 3.2 Scattering of α-particles by gold foil.

- Gold is easily malleable and can be beaten into very thin sheets.
- **Observations made by Rutherford from α-particle scattering experiment**

  (i) Most of the particles passed straight through gold foil without suffering any deflection from their original path.

  (ii) Some of the α-particles were defected by the foil at small angles.

  (iii) One out of every 12000 particles appeared to rebound.

- **Conclusions from Rutherford's α-particles Scattering Experiment :**

  (i) Most of the space inside the atom is empty. Hence it allows the α-particles to pass straight through it without any deflection.

  (ii) Very few partiles were defected from their path, which suggests that the positive charge of the atom occupies very little space.

  (iii) The total volume occupied by a nucleus is very small compared to the total volume of the atom, as very few α-particles are deflected by 180°, and all the positive charge and mass of the gold atom were concentrated in a very small volume with in the atom.

- **Rutherford's nuclear model of an atom**

On the basis of his experiment, Rutherford put forward the nuclear model of an atom, which had the following features :

(i) There is a positively charged centre in an atom called the nucleus and the entire mass of an atom resides in the nucleus.

(ii) Electrons revolve around the nucleus in well defined circular orbits.

(iii) Size of the nucleus is very small as compared to the size of an atom.

- **Defects in Rutherford's model of atom**

  (i) Rutherford had proposed that electrons move around a positively charged nucleus at a very high speed in circular orbits. Electron would have to be accelerated centripetally (tending to move toward a center) to remain in a circular orbit, but according to electron magnetic theory, if charged body (electron) is accelerated around another charged body (nucleus) then there would be continuous radiation of the moving body (i.e. electron). This loss of energy would slow down the speed of electron and eventually electron would fall into the nucleus. But Rutherford's model could not explain such a collapse.

  (ii) Rutherford had proposed that electrons revolve around the nucleus in fixed orbits. He did not specify the number of electrons in each orbit.

➢ **Bohr's model of atom**

In order to overcome the objections raised against Rutherford's model of the atom, Neils Bohr put forward the following postulates about the model of an atom :

(i) Electrons revolve around the nucleus in a limited number of orbits called discrete orbits of electrons that are also called as permissible orbits.

(ii) While revolving in discrete orbits, the electrons does not radiate energy i.e. energy of an electron remains constant so long as it stays in a given orbit. Electrons present in different orbits have different energies.

(iii) When an election jumps from lower energy level to higher energy level some energy is absorbed, while energy is released when electron jumps from higher energy level to lower one.

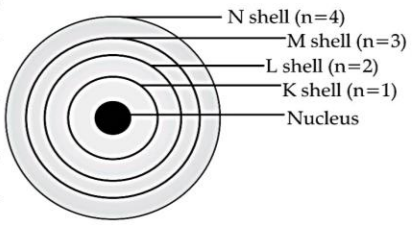


Fig 3.3 A few energy levels in an atom

➢ **Neutrons**

In 1932, James Chadwick discovered another sub atomic particle which has no charge and a mass nearly equal to that of a proton. It was named as neutron. Neutrons are peresent in the nucleus of all atoms, except hydrogen. In general, a neutron is represented as 'n'. The mass of an atom is therefore given by the sum of the masses of protons and neutrons present in the nucleus.

➢ **How are electrons distributed in different orbits (shells)?**

The distribution of electrons into different orbits of an atom was suggested by Bohr and Bury.

The following rules are followed for writing the number of electrons in different energy levels or shells :

(i) Maximum number of electrons that can be accomodated in a shell is given by $2n^2$, where n is the shell number i.e. first shell can accomodate two electrons, second shell can accomodate eight electrons, third shell can accomodate eighteen electrons and so on, the maximum number of electrons in different shells are as follows :

Fisrt orbit or K shell will be $= 2 \times 1^2 = 2$,

Second orbit or L shell will be $= 2 \times 2^2 = 8$,

Third orbit or M shell will be $= 2 \times 3^2 = 18$

Fourth orbit or N shell will be $= 2 \times 4^2 = 32$

(ii) Outermost orbit of an atom can accommodate a maximum number of 8 electrons.

(iii) Electrons are not accomodated in a given shell, unless the inner shells are filled i.e. the shell are filled in a step wise manner. Atomic structure of the first eighteen elements is shown systematically here.

➢ **Valency**

We know that the electrons are negativity charged particles which are arranged is different shells/orbits in an atom. The outermost shell of an atom is called valence shell.

➢ From the Bohr Bury scheme, we also know that the outermost shell of an atom can accomodate a maximum of 8 eletrons. It was observed that the atoms of elements, completely filled with 8 electons in the outermost shell show little chemical activity. In other words, their combining capacity or valency is zero.

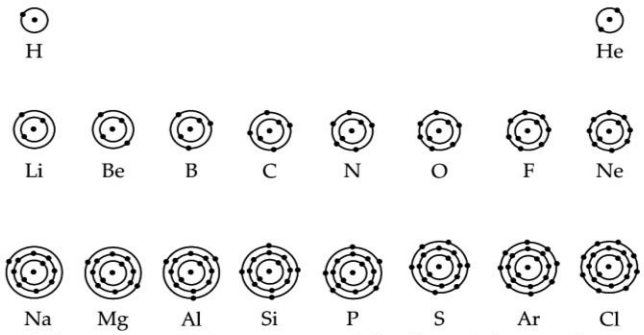


Fig 3.4 Schematic atomic sturcture of the first eighteen elements

➢ **Composition of atoms of the first eighteen elements with electron distribution in various shells**

Name of Element	Symbol	Atomic Number	Number of Protons	Number of Neutrons	Number of Elec-trons	Distributon of Electrons K L M N	Valency
Hydrogen	H	1	1	–	1	1 – – –	1
Helium	He	2	2	2	2	2 – – –	0
Lithium	Li	3	3	4	3	2 1 – –	1
Beryllium	Be	4	4	5	4	2 2 – –	2
Boron	B	5	5	6	5	2 3 – –	3
Carbon	C	6	6	6	6	2 4 – –	4
Nitrogen	N	7	7	7	7	2 5 – –	3
Oxygen	O	8	8	8	8	2 6 – –	2

Fluorine	F	9	9	10	9	2 7 – –	1
Neon	Ne	10	10	10	10	2 8 – –	0
Sodium	Na	11	11	12	11	2 8 1 –	1
Magnesium	Mg	12	12	12	12	2 8 2 –	2
Aluminium	Al	13	13	14	13	2 8 3 –	3
Silicon	Si	14	14	14	14	2 8 4 –	4
Phosphorus	P	15	15	16	15	2 8 5 –	3, 5
Sulphur	S	16	16	16	16	2 8 6 –	2
Chlorine	Cl	17	17	18	17	2 8 7 –	1
Argon	Ar	18	18	22	18	2 8 8 –	0

- Valency of elements having 1 to 4 electons in the outermost shell are generaly determined by the rule :
  Valency = No. of electons is the outermost shell
- Valency of elements having number of electrons in outermost shell close to 8 is determined by the formula :
  Valency = 8 – number of electrons in the outermost shell
- **Significance of valence electrons**
  - **(i)** Valence electrons are responsible for chemical changes.
  - **(ii)** Elements having same number of valence electrons in their atoms possess similar chemical properties because chemical properties of an element are determined by the number of valence electrons in an atom.
  - **(iii)** Elements having different number of valence electrons in their atoms possess different chemical properties.

SELF ASSESSMENT – 1

I. OBJECTIVE TYPE QUESTIONS [1 mark each]

A. Multiple Choice Questions

Q. 1. An alpha particle contains
- **(a)** 4 positive charge and 2 mass unit
- **(b)** 2 positive charge and 4 mass unit
- **(c)** 2 positive charge and 2 mass unit
- **(d)** 4 positive charge and 4 mass unit

Q. 2 In an alpha scattering experiment, few alpha particles rebounded because:
- **(a)** Most of the space in the atom is occupied.
- **(b)** Positive charge of the atoms occupies very little space.
- **(c)** The mass of the atom is concentrated in the centre.
- **(d)** All the positive charge and mass of the atom is concentrated in small volume.

B. Passage Based Questions

Q. 1 Read the following passage and answer the following questions.

In order to overcome the objections raised against Rutherford's model of the atom, Neil Bohr put forward the following postulates about the model of an atom.
- **(i)** Only certain special orbits known as discrete orbits of electrons are allowed inside the atom.
- **(ii)** While revolving in discrete orbits the electrons do not radiate energy. Write the following statements in your answer book after completing them :
  - **(a)** Atoms are made up of _____ , _____ and _____.
  - **(b)** Who amended Rutherford's shortcomings?
  - **(c)** Name the number of electrons that K shell and L shell can accommodate?
  - **(d)** Atomic mass of an element is the sum of the number of protons/electrons and neutrons. (True Or False)

C. Assertion and reason type question.

Directions : In the following questions, a statement of assertion (A) is followed by a statement of reason (R). Mark the correct choice as :
- **(a) Both assertion (A) and reason (R) are true and reason (R) is the correct explanation of assertion (A).**
- **(b) Both assertion (A) and reason (R) are true but reason (R) is not the correct explanation of assertion (A).**
- **(c) Assertion (A) is true but reason (R) is false.**
- **(d) Assertion (A) is false but reason (R) is true.**

Q. 1. Assertion : Cathode rays get deflected towards the positive plate of electric field.
Reason : Cathode rays consists of negatively charged particles known as electron.

Q. 2. Assertion : Electronic configuration of neon is 2, 8
Reason : Atomic number of neon is 10.

D. Very short answer type questions.

AI R **Q. 1.** Which scientist concluded the size of nucleus is very small as compared to size of an atom?

AI K **Q. 2.** What is the electronic configuration of an aluminium atom?

AI R **Q. 3.** Who discovered neutron?

II. SHORT ANSWER TYPE QUESTIONS-I [2 marks each]

Q. 1. There are two elements A_{13}^{26} and B_{14}^{26}. Find the number of sub-atomic particles in each of these elements. What is the relationship between the two? A **(Board Term-II, 2015)**

Q. 2. Illustrate that Na atom has completely filled K and L shells. U **(Board Term-II, 2016)**

III. SHORT ANSWER TYPE QUESTIONS-II [3 marks each]

U **Q. 1.** Write the electronic configuration and valency of the following.

(a) Chlorine (b) Sodium (c) Silicon

R **Q. 2.** (i) What are canal rays ? State the nature of the constituents of canal rays.

(ii) Who discovered canal rays ?

IV. LONG ANSWER TYPE QUESTIONS [5 marks each]

U **Q. 1.** (i) Define valency. What conclusions can be drawn about the reactivity of an atom from its valency ?

(ii) Why does an atom of Argon have zero valency? Explain using the electronic configuration of Argon.

R **Q. 2. Give reasons for the following :**

(i) Isotopes of an element are chemically similar.

(ii) An atom is electrically neutral.

(iii) Noble gases show least reactivity.

(iv) Nucleus of an atom is heavy and positively charged.

(v) Ions are more stable than atoms.

TOPIC-2
Atomic Number, Mass Number, Isotopes and Isobars

Revision Notes

➢ **Atomic Number**

Protons are present in the nucleus of an atom. So, it is the number of protons of an atom, which determine its atomic number. It is denoted by 'Z' (Z = np). The elements are determined by the no. of protons they possess.

For hydrogen, Z = 1, because in hydrogen atom, only one proton is present in the nucleus.

Therefore, the atomic number is defined as the total number of protons present in the nucleus of an atom.

➢ **Mass Number**

Mass of an atom is practically determined due to protons and neutrons alone. These are present in the nucleus of an atom. Hence, protons and neutrons are called nucleons. It is denoted by 'A' ($A = n_p + n_N$).

n_p = No. of protons

n_N = No. of neutrons

For example, mass of carbon is 12 u, because it has 6 protons and 6 neutrons; 6u + 6u = 12u. So, the mass number is defined as the sum of the total no. of protons and neutrons present in the nucleus of an atom.

In the notation for an atom, the atomic number, it mass number and symbol of the element are to be written as:

Mass Number

$$\boxed{\text{Symbol of element}} \quad {}^{A}_{Z}\boxed{X}$$

Atomic Number

➢ **Isotopes:**

1. Isotopes are the atoms of same element having same atomic number but different mass number.
2. They have similar chemical properties because they have same number of valence electrons.

3. They have different physical properties such as boiling point and melting point because they have different mass number.
4. Atomic masses of element are fractional due to the fact that it will contain all the isotopes of that element and the average mass is taken as its atomic mass.

Examples : 3 isotopes of hydrogen are : protium, deuterium and tritium.

➢ **Applications of Isotopes**

1. An isotope of uranium is used in nuclear reactors.
2. An isotope of cobalt is used to remove brain tumors and their treatment.
3. Isotope of sodium has been used to diagnose restricted circulation of blood.

➢ **Isobars**

They are the atoms of different elements with different atomic numbers, but same mass number.

Example : $_{20}Ca^{40}$, $_{18}Ar^{40}$.

SELF ASSESSMENT – 2

I. OBJECTIVE TYPE QUESTIONS [1 mark each]

A. Multiple Choice Questions

AI **Q. 1. How is mass number represented?** R
(a) $A = n_p + n_N$ **(b)** $A = np$
(c) $A = nN$ **(d)** None of these

AI **Q. 2. The atomic number of sodium is 11 and its mass number is 23. It has** R
(a) 11 neutrons and 12 protons
(b) 12 protons and 11 electrons
(c) 11 electrons and 12 neutrons
(d) 12 electrons and 11 neutrons

B. Table Based Questions

R **Q. 1. In the following table, the mass number and the atomic number of certain elements are given. Study the given data and identify the following by giving reason in support of your answer.**

Elements	Mass No.	Atomic No.
A	1	1
B	7	3
C	14	7
D	40	18
E	40	20

(a) cation **(b)** anion
(c) a pair of isotopes **(d)** an atom of noble gas

C. Assertion and Reason Type Questions

Directions : In the following questions, a statement of assertion (A) is followed by a statement of reason (R). Mark the correct choice as:

(a) Both assertion (A) and reason (R) are true and reason (R) is the correct explanation of assertion (A).
(b) Both assertion (A) and reason (R) are true but reason (R) is not the correct explanation of assertion (A).
(c) Assertion (A) is true but reason (R) is false.
(d) Assertion (A) is false but reason (R) is true.

A **Q. 1. Assertion :** The atoms of different elements having same mass number but different atomic number are known as isobars.
Reason : The sum of protons and neutrons, in the isobars is always different.

A **Q. 2. Assertion :** Mass of an atom is the sum of its nucleons.
Reason : Protons and neutrons are present in the nucleus of an atom.

D. Very short answer type question

R **Q. 1.** Which isotope of hydrogen contain same number of electrons, protons and neutrons?.
U **Q. 2.** Identify the pair of isotopes : $^{16}_{8}x$, $^{16}_{7}x$, $^{17}_{8}x$
R **Q. 3.** What is the mass number of Neon?

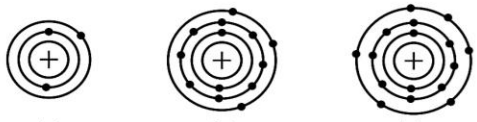
II. SHORT ANSWER TYPE QUESTIONS-I [2 marks each]

Q. 1. What are isotopes? Write three isotopes of hydrogen. Why do isotopes show similar chemical properties? R **(Board Term-II, 2012)**

Q. 2. (i) State the relative mass and charge of the three sub-atomic particles.
(ii) How many sub-atomic particles are found in an atom of Deuterium?
R **(Board Term-II, 2012)**

III. SHORT ANSWER TYPE QUESTIONS-II [3 marks each]

UA **Q. 1.** Find the valency of atoms from figures :-


(a) (b) (c)

K **Q. 2. (i)** Why chemical properties of all the isotopes of an element are same ?

(ii) Name the isotopes used in the treatment of goitre and cancer.

(iii) An element 'X' has 2 electrons in its M shell. What is its atomic number ?

IV. LONG ANSWER TYPE QUESTIONS [5 marks each]

Q. 1. Study the data given below and answer the questions which follows:

Particle	Electrons	Protons	Neutrons
A	2	3	4
B	10	9	8
C	8	8	8
D	8	8	10

(i) Write the mass number and atomic number of particles A, B, C, D.

(ii) Which particle represent a pair of isotopes? Explain.

NCERT CORNER

Intext Exercise

Q. 1. What are canal rays? **[NCERT Q. 1, Page 47]**

Ans. In 1886, Goldstein discovered canal rays. They are positively charged radiations that consists of positively charged particles known as protons.

Q. 2. If an atom contains one electrons and one proton, will it carry any charge or not?[NCERT Q. 2, Page 47]

Ans. A proton is a positively charged particle whereas an electron is a negatively charged particle. The magnitude of their charges is equal. Therefore, an atom containing one electron and one proton will not carry any charge. Thus, it will be a neutral atom.

Q. 3. On the basis of Thomson's model of an atom, explain how the atom is neutral as a whole.

[NCERT Q. 1, Page 49-I]

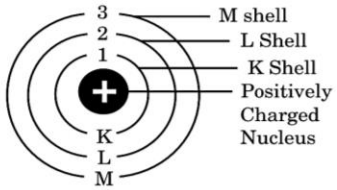
Ans. According to Thomson's model of the atom, an atom contains both positively and negatively charged particles. The negatively charged particles are studded in the positively charged sphere, like the seeds in a watermelon. These negative and positive charges are equal in magnitude. Thus, by counter balancing each other's effect, they make an atom neutral.

Q. 4. On the basis of Rutherford's model of an atom, which subatomic particle is present in the nucleus of an atom? **[NCERT Q. 2, Page 49-I]**

Ans. On the basis of Rutherford's model of an atom, protons (positively-charged particles) are present in the nucleus of an atom.

Q. 5. Draw a sketch of Bohr's model of an atom with three shells. **[NCERT Q. 3, Page 49]**

Ans.



Q. 6. What do you think would be the observation if the α-particle scattering experiment is carried out using a foil of a metal other than gold?

[NCERT Q. 4, Page 49]

Ans. If the α-particle scattering experiment is carried out using a foil of a metal rather than gold, there would be no change in the observation. In the α-scattering experiment, a gold foil was taken because gold is malleable and can be fold easily or a thin foil of gold can be easily made. Also, it is difficult to make such foils from other metals.

Q. 7. Name the three sub-atomic particles of an atom.

[NCERT Q. 1, Page 49-II]

Ans. The three sub-atomic particles of an atom are :
(i) Protons **(ii)** Electrons **(iii)** Neutrons.

Q. 8. Helium atom has an atomic mass of 4 u and two protons in its nucleus. How many neutrons does it have? **[NCERT Q. 2, Page 49-II]**

Ans. Helium has two neutrons. The mass of an atom is equal to the sum of the masses of protons and neutrons present in its nucleus. Mean while, helium atom has two protons, mass contributed by the two protons is $(2 \times 1)u = 2u$. Then, the remaining mass $(4 - 2)$ u is contributed by $\frac{2u}{1u} = 2$ neutrons.

Q. 9. Write the distribution of electrons in carbon and sodium atoms? **[NCERT Q. 1, Page 50]**

Ans. The total number of electrons in a carbon atom is 6. The distribution of electrons in carbon atom is given by :

First orbit or K-shell = 2 electrons

Second orbit or L-shell = 4 electrons

Thus, the distribution of electrons in a carbon atom will be 2, 4.

The total number of electrons in a sodium atom is 11. The distribution of electrons in sodium atom is given by :

First orbit or K-shell = 2 electrons

Second orbit or L-shell = 8 electrons

Third orbit or M-shell = 1 electron

Thus, the distribution of electrons in a sodium atom as 2, 8, 1.

Q. 10. If K and L shells of an atom are full, then what would be the total number of electrons in the atom?

[NCERT Q. 2, Page 50]

Ans. The maximum number of electrons that can occupy K and L shells of an atom are 2 and 8, respectively. Thus, if K and L shells of an atom are full, then the total number of electrons in the atom would be (2 + 8) = 10.

Q. 11. How will you find the valency of chlorine, sulphur and magnesium? **[NCERT Q. 1, Page 52-I]**

Ans. If the number of electrons in the outermost shell of the atom of an element is less than or equal to 4, then the valency of the element is equal to the number of electrons present in its outermost shell and if the number of electrons in the outermost shell of the atom of an element is greater than 4, then the valency of that element is determined by subtracting the number of electrons in the outermost shell from 8.

The distribution of electrons in

Chlorine is 2, 8, 7.

Sulphur is 2, 8, 6.

Magnesium atom is 2, 8, 2.

Thus, the number of electrons in the outermost shells of chlorine, sulphur and magnesium atoms are 7, 6, and 2, respectively.

Therefore,

The valency of chlorine = 8 − 7 = 1

The valency of sulphur = 8 − 6 = 2

The valency of magnesium = 2.

Q. 12. If number of electrons in an atom is 8 and number of protons is also 8, then

(i) What is the atomic number of the atom and

(ii) What is the charge on the atom?

[NCERT Q. 1, Page 52-II]

Ans. **(i)** The atomic number is equal to the number of protons. Thus, the atomic number of the atom is 8.

(ii) As, the number of both protons and electrons is equal, the charge on the atom is 0.

Q. 13. With the help of the following table, find out the mass number of oxygen and sulphur atom.

[NCERT Q. 2, Page 52-II]

Name of element	Symbol	Atomic number	Number of protons	Number of neutrons	Number of electrons	Distribution of electrons				Valency
						K	L	M	N	
Hydrogen	H	1	1	-	1	1	-	-	-	1
Helium	He	2	2	2	2	2	-	-	-	0
Lithium	Li	3	3	4	3	2	1	-	-	1
Beryllium	Be	4	4	5	4	2	2	-	-	2
Boron	B	5	5	6	5	2	3	-	-	3
Carbon	C	6	6	6	6	2	4	-	-	4
Nitrogen	N	7	7	7	7	2	5	-	-	3
Oxygen	O	8	8	8	8	2	6	-	-	2
Fluorine	F	9	9	10	9	2	7	-	-	1
Neon	Ne	10	10	10	10	2	8	-	-	0
Sodium	Na	11	11	12	11	2	8	1	-	1
Magnesium	Mg	12	12	12	12	2	8	2	-	2
Aluminium	Al	13	13	14	13	2	8	3	-	3
Silicon	Si	14	14	14	14	2	8	4	-	4
Phosphorus	P	15	15	16	15	2	8	5	-	3,5
Sulphur	S	16	16	16	16	2	8	6	-	2
Chlorine	Cl	17	17	18	17	2	8	7	-	1
Argon	Ar	18	18	22	18	2	8	8		0

Ans. Mass number of oxygen = Number of protons + Number of neutrons = 8 + 8 = 16

Mass number of sulphur = Number of protons + Number of neutrons = 16 + 16 = 32

Q. 14. For the symbol H, D and T tabulate three sub-atomic particles found in each of them. [NCERT Q. 1, Page 53]

Ans.

Symbol	Proton	Neutron	Electron
H	1	0	1
D	1	1	1
T	1	2	1

Q. 15. Write the electronic configuration of any pair of isotopes and isobars. [NCERT Q. 2, Page 53]

Ans. Isotopes have same electronic configuration as the atoms have the same atomic number but different mass numbers.

Isotopes of chlorine are $^{35}Cl_{17}$ and $^{37}Cl_{17}$

Since Isotopes of elements have same atomic number. So, there is no change in electronic configuration = 2,8,7

Isotopes of carbon are $^{12}C_6$, $^{13}C_6$ and $^{14}C_6$

Electronic configuration= 2, 4

$^{40}Ca_{20}$ and $^{40}Ar_{18}$ are a pair of isobars having atomic number 20 and 18

The electronic configuration of $^{40}Ca_{20}$ = 2, 8, 8, 2.

The electronic configuration of $^{40}Ar_{18}$ = 2, 8, 8.

Since all the isotopes of an element have identical electronic configuration containing the same number of valance electrons therefore all the isotopes of an element show identical chemical properties. Isobars have different chemical properties because they have different atomic number and different electronic configurations.

NCERT Exercise

Q. 1. Compare the properties of electrons, protons and neutrons.

Ans.

S.No.	Electrons	Protons	Neutrons
1.	Negatively charged	Positively charged	No charge
2.	Mass is negligible (1/8000 times of protons.	Mass is 1 a.m.u	Mass is 1 a.m.u.
3.	Gets attract-ed towards +ve charge	Get at-tracted towards -ve charge.	Do not get attracted, as they are neutral.
4.	Present outside the nucleus.	Present in the nucleus	Present in the nucleus of an atom.

Q. 2. What are the limitations of J.J. Thomson's model of the atom?

Ans. Limitations of J.J Thomson's model of an atom are:

(a) It could not explain the result of the scattering experiment performed by Rutherford.

(b) It did not have any experimental evidence in its support.

Q. 3. What are the limitations of Rutherford's model of the atom?

Ans. Limitations of Rutherford's model of the atom are:

(a) It does not explain the stability of atom.

(b) It does not explain the spectrum of hydrogen and other atoms.

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

Ans. Bohr proposed the following postulates for revising the Rutherford's model.

(a) Atom has central nucleus surrounded by electrons.

(b) An atom consists of small heavy positively charged nucleus in the centre and the electrons revolve around it. in circular paths called orbits or shells.

(c) Each orbit has fixed energy, so these orbits are called energy levels or energy shells.

(d) The order of the energy of these energy shells will be :

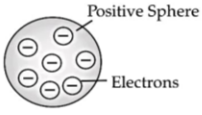
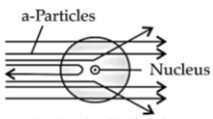
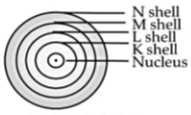
K < L< M < N < 0 <..... or, 1 < 2 < 3 < 4 < 5 <.....

(e) As long as an electron remains in a particular orbit, it does not lose or gain energy.

(f) Energy is neither absorbed nor emitted when electron is moving in an orbit. But energy is absorbed when it jumps from lower orbit to higher orbit. Whereas energy is emitted when it jumps from higher orbit to lower orbit.

Q. 5. Compare all the proposed models of an atom given in this chapter.

Ans. Comparison of different proposed Model:

Thomson	Rutherford	Bohr
Sphere of positive charge	Sphere of positive charge in centre called nucleus. All mass of an atom resides in the nucleus	Positive charge in centre called nucleus.
Electrons are spread randomly all over in the sphere	Electrons revolve around the nucleus in well defined orbits.	Electrons revolve in discrete orbits and do not radiate energy.
 Thomson's Modal	 Rutherford Model	 Bohr's Model
Positive charge = Negative charge. Atom is electrically neutral.	Size of nucleus is very small as com-pared to size of atom.	The orbits were termed as energy shells labelled as K, L. M, N or n= 1, 2, 3, 4 (numbered)

Q. 6. Summarise the rules for writing of distribution of electrons in various shells for the first eighteen elements.

Ans. The distribution of elements in different orbits is governed by a scheme called Bohr-Bury scheme.

Rules for Bohr-Bury scheme are:

(i) The maximum number of electrons present in any shell is given by the formula Inl. Where n = no. of orbit.

(ii) The maximum number of electrons that can be accommodated in the outermost shell is 8.

(iii) Electrons in an atom do not occupy a new shell unless all the inner shells are completely filled.

Q. 7. Define valency by taking examples of silicon and oxygen.

Ans. Valency is the number of electrons gained, lost or shared so as to complete the octet of electrons in valence shell.

Valency of silicon: It has electronic configuration as 2,8.4 Thus, 4 electrons are shared with other atoms to complete the octet and so its valency = 4

Valency of oxygen : It has electronic configuration as 2,6 Thus, It will gain 2 electrons to complete its octet. So its valency = 2

Q. 8. 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 atomic number of an element is equal to the number of protons in the nucleus of its atom, e.g., Oxygen has 6 protons, hence its atomic no. is 6.

(ii) Mass number: The mass number of an atom is equal to the number of protons and neutrons in its nucleus.

Nuclcons = number of protons i number of neutrons

E.g. : Protons + Neutrons = Nucleus = Mass number i.e. Mass number of oxygen is 6 + 6 = 12

(iii) Isotopes: Isotopes are atoms of the same element which have different mass number but same atomic number.

E.g., $^{1}_{1}H$, $^{2}_{1}H$, $^{3}_{1}H$

(iv) Isobars: Isobars are atoms having the same mass number but different atomic numbers.

E.g., $^{40}_{20}Ca$, $^{40}_{18}Ar$

Both calcium and argon have same mass number but different atomic number.

Two uses of isotopes are:

(i) An isotope of iodine is used in the treatment of goitre.

(ii) An isotope of uranium is used as a fuel in nuclear reactors

Q. 9. Na^+ has completely filled K and L shells. Explain.

Ans. Sodium atom (Na), has atomic number =11

Number of protons =11

Number of electrons = 11

Electronic configuration of Na = K L M = 2 8 1

Sodium atom (Na) looses 1 electron to become stable and form Na+ ion. Hence it has completely filled K and L shells.

If bromine atom is available in the form of, say, two isotopes $^{79}_{35}Br$ (49.7%) and $^{81}_{35}Br$ (50.3%), calculate the average atomic

Q. 10. mass of bromine atom.

Ans. The average atomic mass of bromine atom

$$= \left(79\times\frac{49.7}{100}\right)+\left(81\times\frac{50.3}{100}\right)$$

$$= 39.263 + 40.743$$

$$= 80.006 \text{ u}$$

The average atomic mass of a sample of an element X is 16.2 u.

Q. 11. What are the percentages of isotopes $^{16}_{8}X$ and $^{18}_{8}X$ in the Sample ?

Ans. Let the percentage of $^{16}_{8}$ X be x and the percentage of $^{18}_{8}$ X be 100 – x.

$$\left(16\times\frac{x}{100}\right)+\frac{18(100-x)}{100}=16.2$$

$$\frac{16x}{100}+\frac{1800-18x}{100}=16.2$$

$$\frac{16x-18x+1800}{100}=16.2$$

$$-2x + 1800 = 16.2 \times 100$$

$$-2x = 1620 - 1800$$

$$-2x = -180$$

$$x = \frac{180}{2} = 90$$

$$^{16}_{6}X = 90\%$$

and $$^{18}_{8}X = 10\%$$

Q. 12. If Z = 3, what would be the valency of the element? Also, name the element.

Ans. Z = 3, (i.e, atomic number → z)

∴ Electronic configuration = 2, 1

Valency = 1

Name of the element is lithium

Composition of the nuclei of two atomic species X and Y are given as under

	X	Y
Protons =	6	6
Neutrons =	6	8

Q. 13. Give the mass numbers of X and Y. What is the relation between the two species?

Ans. Mass number of X = Protons + Neutrons = 6 + 6 = 12

Mass number of Y = Protons + Neutrons = 6 + 8 = 14

As the atomic number is same i.e., = 6.

[atomic number = number of protons].

Both X and Y are isotopes of same element.

Q. 14. For the following statements, write T for True and F for False.

(a) J.J. Thomson proposed that the nucleus of an atom contains only nucleons.

(b) A neutron is formed by an electron and a proton combining together. Therefore, it is neutral.

(c) The mass of an electron is about 1/2000 times that of proton.

(d) An isotope of iodine is used for making tincture iodine, which is used as a medicine.

Ans. (a) False (b) False (c) True (d) False

Directions : Put tick (3) against correct choice and cross (7) against wrong choice in questions 15,16 and 17

Q. 15. Rutherford's alpha-particle scattering experiment was responsible for the discovery of

(a) Atomic Nucleus (b) Electron

(c) Proton (d) Neutron

Ans. (a) Atomic nucleus

Q.16. Isotopes of an element have

(a) the same physical properties

(b) different chemical properties

(c) different number of neutrons

(d) different atomic numbers.

Ans. (c) different number of neutrons

Q.17. Number of valence electrons in Cl^- ion are:

(a) 16 (b) 8

(c) 17 (d) 18

Ans. (b) 8

Q. 18. Which one of the following is a correct electronic configuration of sodium?

(a) 2, 8 (b) 8, 2, 1

(c) 2, l, 8 (d) 2, 8, 1.

Ans. (d) 2, 8, 1

Q. 19. Complete the following table.

Atomic Number	Mass Number	Number of Neutrons	Number of Protons	Number of Electrons	Number of the atomic species
9	–	10	–	–	–
16	32	–	–	–	Sulphur
–	24	–	12	–	–
–	2	–	1	–	–
–	1	0	1	0	–

Ans.

Atomic Number	Mass Number	Number of Neutrons	Number of Protons	Number of Electrons	Number of the atomic species
9	19	10	9	9	Fluorine
16	32	16	16	16	Sulphur
12	24	12	12	12	Magnesium
1	2	1	1	1	Hydrogen Deuterium
1	1	0	1	0	Hydrogen

NCERT Exemplar

Multiple Choice Questions

Q. 1. Which of the following correctly represents the electronic distribution in the Mg atom?

(a) 3, 8, 1 **(b)** 2, 8, 2

(c) 1, 8, 3 **(d)** 8, 2, 2

Ans. Correct option : (b)

Explanation : Atomic number of Magnesium = 12

So, electronic distribution will be : 2, 8, 2.

Q. 2. Rutherford's alpha (α) particles scattering experiment resulted in to discovery of

(a) Electron.

(b) Proton.

(c) Nucleus in the atom.

(d) Atomic mass.

Ans. Correct option : (c)

Explanation : According to Rutherford's model of an atom, electron revolves around the nucleus in fixed orbits. The mass and positive charge of the atom are concentrated in the nucleus and most of the space in atom is empty.

Q. 3. The number of electrons in an element X is 15 and the number of neutrons is 16. Which of the following is the correct representation of the element?

(a) $^{31}_{15}X$ **(b)** $^{31}_{16}X$

(c) $^{16}_{15}X$ **(d)** $^{15}_{16}X$

Ans. Correct option : (a)

Explanation : Given that, number of electrons in element X = 15 and number of neutrons = 16

Atomic number = number of protons = number of electrons in neutral atom = 15

Mass number = number of protons + number of neutrons = 15 + 16 = 31

Thus, the atom is represented as $^{31}_{15}X$

Q. 4. Dalton's atomic theory successfully explained

(i) Law of conservation of mass.

(ii) Law of constant composition.

(iii) Law of radioactivity.

(iv) Law of multiple proportion.

(a) (i), (ii) and (iii) **(b)** (i), (iii) and (iv)

(c) (ii), (iii) and (iv) **(d)** (i), (ii) and (iv)

Ans. Correct option : (d)

Explanation : Dalton's atomic theory successfully explained the laws of chemical combination, that is, law of conservation of mass, law of constant composition and law of multiple proportion, but not explained about radioactivity.

Q. 5. Which of the following statements about Rutherford's model of atom are correct?

(i) Considered the nucleus as positively charged.

(ii) Established that the α–particles are four times as heavy as a hydrogen atom.

(iii) Can be compared to solar system.

(iv) Was in agreement with Thomson's model.

(a) (i) and (iii) **(b)** (ii) and (iii)

(c) (i) and (iv) **(d)** only (i)

Ans. Correct option : (a)

Explanation : Rutherford's model of atom is considered the nucleus as positively charged and can be compared to solar system.

Q. 6. Which of the following are true for an element?

(i) Atomic number = number of protons + number of electrons

(ii) Mass number = number of protons + number of neutrons

(iii) Atomic mass = number of protons = number of neutrons

(iv) Atomic number = number of protons = number of electrons

(a) (i) and (ii) **(b) (i) and (iii)**

(c) (ii) and (iii) **(d) (ii) and (iv)**

Ans. Correct option : (d)

Explanation : Mass number = Number of protons + Number of neutrons and

Atomic number = Number of protons = Number of electrons

Q. 7. In the Thomson's model of atom, which of the following statements are correct?

(i) The mass of the atom is assumed to be uniformly distributed over the atom.

(ii) The positive charge is assumed to be uniformly distributed over the atom.

(iii) The electrons are uniformly distributed in the positively charged sphere.

(iv) The electrons attract each other to stabilize the atom.

(a) (i), (ii) and (iii) **(b)** (i) and (iii)

(c) (i) and (iv) **(d)** (i), (iii) and (iv)

Ans. Correct option : (a)

Explanation : The mass of the atom is assumed to be uniformly distributed over the atom with the positive charge is assumed to be uniformly distributed over the atom and the electrons are uniformly distributed in the positively charged sphere.

Q. 8. Rutherford's α-particle scattering experiment showed that :

(i) Electrons have negative charge.

(ii) The mass and positive charge of the atom is concentrated in the nucleus.

(iii) Neutron exists in the nucleus.

(iv) Most of the space in atom is empty.

Which of the above statements are correct?

(a) (i) and (iii) **(b)** (ii) and (iv)

(c) (i) and (iv) **(d)** (iii) and (iv)

Ans. Correct option : (b)

Explanation : The mass and positive charge of the atom are concentrated in the nucleus and most of the space in atom is empty.

Q. 9. The ion of an element has 3 positive charges. Mass number of the atom is 27 and the number of neutrons is 14. What is the number of electrons in the ion?

(a) 13 **(b)** 10

(c) 14 **(d)** 16

Ans. Correct option : (b)

Explanation : Mass number of the atom is 27.

The number of neutrons is 14.

Mass number = Number of protons + Number of neutrons

$$27 = P + 14$$

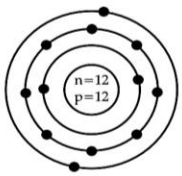
$$P = 27 - 14 = 13$$

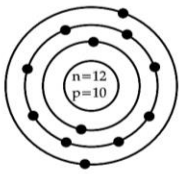
Number of protons = Number of electrons

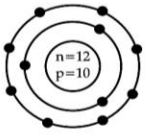
Number of electrons in the atom = 13

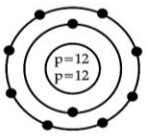
Now, three electrons lose to form ion with three positive charges. So, the number of electrons in the positive charged ion = 10.

Q. 10. Identify the Mg^{2+} ion from the given figure, where, n and p represent the number of neutrons and protons respectively.

(a) 

(b) 

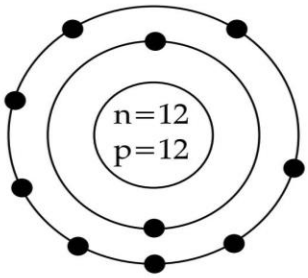
(c) 

(d) 

Ans. Correct option : (d)

Explanation : K, L, M

Electronic configuration $_{12}Mg$ atom = 2, 8, 2 and that of Mg^{2+} ion = 2, 8



Number of protons in Mg atom = 2+ 8 + 2 = 12

Number of neutrons in Mg atom = 24 -12 = 12

[as mass number of Mg atom = 24 and number of neutrons = mass number – number of protons]

Q. 11. In a sample of ethyl ethanoate ($CH_3COOC_2H_5$) the two oxygen atoms have the same number of electrons but different number of neutrons. Which of the following is the correct reason for it?

(a) One of the oxygen atoms has gained electrons.

(b) One of the oxygen atoms has gained two neutrons.

(c) The two oxygen atoms are isotopes.

(d) The two oxygen atoms are isobars.

Ans. Correct option : (c)

Explanation : A number of atoms of some elements have the same atomic number (electrons) but different mass numbers (different number of neutrons) are known as isotopes.

Q. 12. Elements with valency one are

(a) always metals.

(b) always metalloids.

(c) either metals or non-metals.

(d) always non-metals.

Ans. Correct option : (c)

Explanation : Metals are elements which lose electron to form cations. Non-metals are elements gain electron to form anions. Alkali metals and halogens (non-metal) have valency one.

Q. 13. The first model of an atom was given by

(a) N. Bohr **(b) E. Goldstein**

(c) Rutherford **(d) J.J. Thomson**

Ans. Correct option : (d)

Explanation : J. J. Thomson was the first scientist to propose a model for structure of an atom. When J. J. Thomson proposed his model of the atom in 1903, then only electrons and protons were known to be present in the atom. According to him, an atom consists of a sphere of positive charge with negatively charged electrons embedded in it.

Q. 14. An atom with 3 protons and 4 neutrons will have a valency of

(a) 3 **(b)** 7

(c) 1 **(d)** 4

Ans. Correct option : (c)

Explanation : The atomic number is the total number of protons present in the nucleus of an atom. Then electronic configuration will be 2, 1. Thus, the valency will be one.

Q. 15. The electron distribution in an aluminium atom is

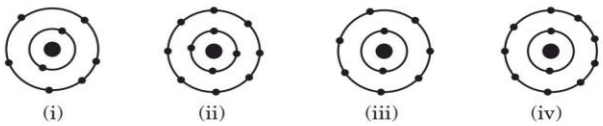
(a) 2, 8, 3 **(b) 2, 8, 2**

(c) 8, 2, 3 **(d) 2, 3, 8**

Ans. Correct option : (a)

Explanation : Atomic number of aluminium is 13, then its electronic configuration will be 2, 8, 3.

Q. 16. Which of the following in figure do not represent Bohr's model of an atom correctly?



(a) (i) and (iii) **(b)** (ii) and (iii)

(c) (ii) and (iv) **(d)** (i) and (iv)

Ans. Correct option : (c)

Explanation : The distribution of electrons into different orbits of an atom was suggested by Bohr and Bury. The following rules are used for writing number of electrons in different energy levels or shells.

(i) Maximum number of electrons present in a shell is given by the formula $2n^2$, where 'n' is the orbit number or energy level index, 1, 2, 3, ….Hence the maximum number of electrons in different shells are as follows : First orbit or K-shell will be $2 \times 1^2 = 2$, second orbit or L shell will be $2 \times 2^2 = 8$, In the given question, image (ii) has 4 electrons in inner shell and in image (iv) has 9 electrons in outer shell which is not according to Bohr's atomic model.

Q. 17. Which of the following statements is always correct?

(a) An atom has equal number of electrons and protons.

(b) An atom has equal number of electrons and neutrons.

(c) An atom has equal number of protons and neutrons.

(d) An atom has equal number of electrons, protons and neutrons.

Ans. Correct option : (a)

Explanation : An atom has an equal number of electrons and protons because equal number of negative electric charge (the electrons) and positive electric charge (the protons) make the total electric charge of the atom to zero and the atom is said to be neutral.

Q. 18. Atomic models have been improved over the years. Arrange the following atomic models in the order of their chronological order.

(i) Rutherford's atomic model.

(ii) Thomson's atomic model.

(iii) Bohr's atomic model.

(a) (i), (ii) and (iii) **(b)** (ii), (iii) and (i)

(c) (ii), (i) and (iii) **(d)** (iii), (ii) and (i)

Ans. Correct option : (c)

Explanation :

(i) Thomson's atomic model has improved in 1897.

(ii) Rutherford's atomic model has improved in 1911.

(iii) Bohr's atomic model has improved in 1915.

Short Answer Questions

Q. 19. Is it possible for the atom of an element to have one electron, one proton and no neutron? If so, name the element.

Ans. Yes, it is possible for the atom of an element to have one electron, one proton and no neutron. This is true for hydrogen atom which is represented as $^{1}_{1}H$.

Q. 20. Write any two observations which support the fact that atoms are divisible.

Ans. Two observations which support the fact that atoms are divisible are :

(i) The discovery of electron.

(ii) The discovery of proton.

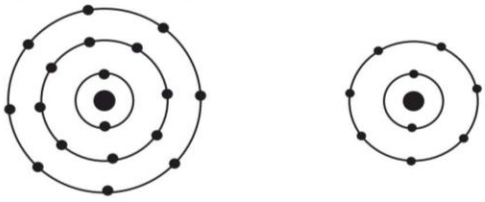
Q. 21. Will ^{35}Cl and ^{37}Cl have different valencies? Justify your answer.

Ans. ^{35}Cl and ^{37}Cl are isotopes, that is, they have same atomic number but different mass numbers. Thus, they will not have different valencies.

Q. 22. Why did Rutherford select a gold foil in his α-rays scattering experiment ?

Ans. Rutherford choose gold foil for his experiment because gold is highly malleable metal and he wanted the thinnest layer as possible. So, gold can be hit and flattened to sheets easily and it will yield very thin layer.

Q. 23. Find out the valency of the atoms represented by the figures (a) and (b).



(a) **(b)**

Ans. **(a)** The valency of atom shown in figure (a) is 0.

(b) The valency of atom shown in figure (b) is 1.

Q. 24. One electron is present in the outermost shell of the atom of an element X. What would be the nature and value of charge on the ion formed if this electron is removed from the outermost shell?

Ans. One electron is present in the outermost shell of the atom of an element X. If this electron is removed from the outermost shell, then the nature and value of charge on the ion formed will be + 1.

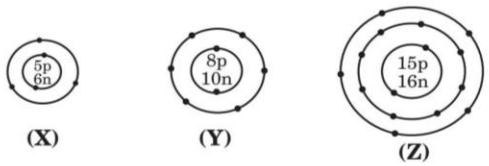
Q. 25. Write down the electron distribution of chlorine atom. How many electrons are there in the L-shell? (Atomic number of chlorine is 17)

Ans. The electron distribution of chlorine atom will be 2, 8, 7. In the L-shell the maximum number of electrons will be eight. But for chlorine the number of electrons I-shell is 7.

Q. 26. In the atom of an element X, 6 electrons are present in the outermost shell. If it acquires noble gas configuration by accepting requisite number of electrons, then what would be the charge on the ion so formed?

Ans. In the atom of an element X, 6 electrons are present in the outermost shell. When it acquires noble gas configuration by accepting requisite number of electrons, then the charge on the ion so formed will be −2, as it requires 2 electrons to complete its octet.

Q. 27. What information do you get from the figure about the atomic number, mass number and valency of atoms X, Y and Z? Give your answer in a tabular form.



(X) **(Y)** **(Z)**

Ans.

Atom	Atomic number	Mass number	Valency
X	5	11	3
Y	8	18	2
Z	15	31	3, 5

Q. 28. In response to a question, a student stated that in an atom, the number of protons is greater than the number of neutrons, which in turn is greater than the number of electrons. Do you agree with the statement? Justify your answer.

Ans. The statement given by the student stated that, "In an atom, the number of protons is greater than the number of neutrons, which in turn is greater than the number of electrons", is incorrect. In an atom, the number of protons and electrons is always equal.

Q. 29. Calculate the number of neutrons present in the nucleus of an element X which is represented as $^{31}_{15}X$.

Ans. Mass number = Number of protons + Number of neutrons = 31

Therefore, Number of neutrons = 31 – Number of protons

= 31 – 15

= 16

Q. 30. Match the names of the scientists given in column A with their contributions towards the understanding of the atomic structure as given in column B.

(A)	(B)
(a) Ernest Rutherford	(i) Indivisibility of atoms
(b) J. J. Thomson	(ii) Stationary orbits
(c) Dalton	(iii) Concept of nucleus
(d) Neils Bohr	(iv) Discovery of electrons
(e) James Chadwick	(v) Atomic number
(f) E. Goldstein	(vi) Neutron
(g) Mosley	(vii) Canal rays

Ans. **(a)** (iii) **(b)** (iv)
(c) (i) **(d)** (ii)
(e) (vi) **(f)** (vii)
(g) (v)

Q. 31. The atomic number of calcium and argon are 20 and 18 respectively, but the mass number of both these elements is 40. What is the name given to such a pair of elements?

Ans. Isobars are the atoms of different elements with different atomic numbers, which have the same mass number. In this question, the atomic number of calcium and argon are 20 and 18, respectively, but the mass number of both these elements is 40. Hence, calcium and argon are called isobars.

Q. 32. Complete the following table on the basis of information available in the symbols given below.

(a) $^{35}_{17}Cl$ **(b)** $^{12}_{6}C$ **(c)** $^{81}_{35}Br$

Element	n_p	n_n

Ans.

Element	n_p	n_n
Cl	17	18
C	6	6
Br	35	46

Q. 33. Helium atom has 2 electrons in its valence shell but its valency is not 2. Explain.

Ans. Helium atom has 2 electrons in its outermost shell and its duplet is complete. Therefore, its valency is zero but not 2.

Q. 34. Fill in the blanks in the following statements.

(a) Rutherford's α-particle scattering experiment led to the discovery of the _____.

(b) Isotopes have same _____ but different _____.

(c) Neon and chlorine have atomic numbers 10 and 17 respectively. Their valencies will be _____ and _____ respectively.

(d) The electronic configuration of silicon is _____ and that of sulphur is _____.

Ans. **(a)** atomic nucleus
(b) atomic number, mass number
(c) 0 , 1.
(d) 2, 8, 4; 2, 8, 6

Q. 35. An element X has a mass number 4 and atomic number 2. Write the valency of this element?

Ans. The atomic number of the element is 2, this means that K-shell is completely filled. So, its valency is zero.

Long Answer Questions

Q. 36. Why do helium, neon and argon have a zero valency?

Ans. Helium, neon and argon have a zero valency because :

(i) They are noble gases and their octets (duplet in case of helium) are already completed.

(ii) Helium has two electrons in its only energy shell, while argon and neon have 8 electrons in their valence shells.

(iii) Helium, neon and argon have stable electronic configuration.

(iv) They neither lose electrons nor gain.

(v) They have maximum number of electrons in their valence shells. They do not have any tendency to combine with other elements. Hence, they have a valency equal to zero.

Q. 37. The ratio of the radii of hydrogen atom and its nucleus is $\sim 10^5$. Assuming the atom and the nucleus to be spherical, (i) what will be the ratio of their sizes? (ii) If atom is represented by planet earth 'R_e' = 6.4×10^6 m, estimate the size of the nucleus.

Ans. **(i)** Volume of the sphere $= \frac{4}{3}\pi R^3$

Let R be the radius of the atom and r be that of the nucleus.

$R = 10^5 r$

$$\text{Volume of the atom} = \frac{4}{3}\pi R^3$$

$$= \frac{4}{3}\pi\left(10^5 r\right)^3$$

$$= \frac{4}{3}\pi r^3 \times 10^{15}$$

$$\text{Volume of the nucleus} = \frac{4}{3}\pi r^3$$

Ration of the size of atom to that of nucleus

$$= \frac{\frac{4}{3}\pi \times 10^{15} r^3}{\frac{4}{3}\pi r^3}$$

$$= 10^{15} : 1$$

(ii) If the atom is represented by the planet earth (R_e = 6.4×10^6 m), then the radius of the nucleus would be

$$r_n = \frac{R_e}{10^5}$$

$$r_n = \frac{6.4 \times 10^6 \text{ m}}{10^5}$$

$$= 6.4 \times 10 \text{ m}$$

$$= 64 \text{ m}$$

Q. 38. Enlist the conclusions drawn by Rutherford from his α-particle scattering experiment.

Ans. From the α-particle scattering experiment, Rutherford concluded that

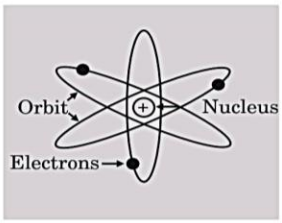
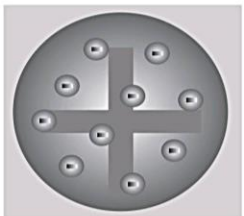
(i) The atoms contain empty space inside it because most of the α-particles are passed through the gold foil without getting deflected.

(ii) The positive charge of the atom occupies very little space as very few particles were deflected from their path.

(iii) All the positive charge and mass of the gold atom were concentrated in a very small volume with in the atom because a very small fraction of α-particles were deflected by 180°.

Q. 39. In what way is the Rutherford's atomic model different from that of Thomson's atomic model?

Ans.

Rutherford's atomic model	Thomson's atomic model
Rutherford model of atom is the model which explains that there is a nucleus in the center of the atom and electrons are located around the nucleus.	Thomson model of atom is the model which states that electrons are embedded in a positively charged solid material which is spherical in shape.
Rutherford model of atom provides details about the nucleus of an atom and its location inside the atom.	Thomson model of atom does not give any detail about the nucleus.
Rutherford model says electrons are located around the nucleus.	According to Thomson model of atom, electrons are embedded in a solid material.
Rutherford model of atom explains about orbitals and that electrons are located in these orbitals.	Thomson model of atom does not give details about orbitals.
According to the Rutherford model of atom, the mass of an atom is concentrated in the nucleus of the atom.	Thomson model of atom explains that the mass of an atom is the mass of positively charged solid where electrons are embedded
	

Q. 40. What were the drawbacks of Rutherford's model of an atom?

Ans. The drawbacks of Rutherford's model of an atom is that the orbital revolution of the electron is not expected to be steady. Any particle in a circular orbit radiates energy when undergoes acceleration. Therefore, the rotating electron would lose energy and finally fall into the nucleus. If this were so, the atom should be highly unstable and later matter would not exist in its actual form.

Q. 41. What are the postulates of Bohr's model of an atom?

Ans. Bohr's Model of an Atom :

(i) An atom consists of a positively charged centre called the nucleus where the whole mass of the atom is concentrated.

(ii) Electrons revolve in orbits with discrete energy levels.

(iii) Under normal conditions, the energy of the 1st energy level will be lowest, say E1. Other orbits, 2nd, 3rd ..... will have energies E2, E3 .....

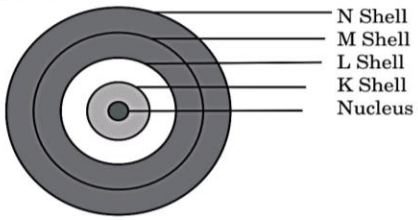
(iv) As long as an electron revolves in the same orbit, it does not radiate energy levels.

(v) When we supply energy to an electron, it can go to higher energy levels.

(vi) When an electron falls from a higher energy level to a lower energy level, the difference in energy between the two energy levels is radiated.

(vii) Since each atom has its specific energy levels, it can emit radiations of specific wavelengths or energy which leads to characteristic spectra of different atoms.

(viii) The discrete orbits or shells are shown in the following diagram.

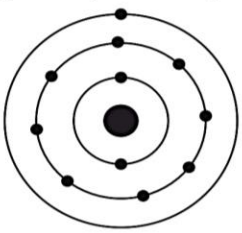


These orbits or shells are called energy levels. The first orbit (*i.e.*, for $n = 1$) is represented by letter K. Similarly, for $n = 2$, it is L-shell, for $n = 3$, it is M-shell and for $n = 4$, it is N-shell. These orbits or shells are also called energy levels.

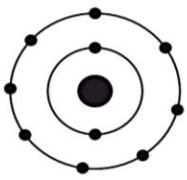
Q. 42. Show diagrammatically the electron distributions in a sodium atom and a sodium ion and also give their atomic numbers.

Ans. As the atomic number of sodium atom is 11, it means it has 11 electrons. A positively charged sodium ion (Na^+) is formed by the removal of one electron from a sodium atom. So, a sodium ion has $11 - 1 = 10$ electrons in it.

Thus, electronic distribution of sodium ion will be 2, 8. The atomic number of an element is equal to the number of protons in its atom. Because, sodium atom and sodium ion contain the same number of protons, therefore, the atomic number of both is 11.



Sodium atom



Sodium ion

Q. 43. In the gold foil experiment of Geiger and Marsden, that paved the way for Rutherford's model of an atom, ~1.00% of the α-particles were found to deflect at angles 50. If one mole of α-particles were bombarded on the gold foil, compute the number of α-particles that would deflect at angles less than 50°.

Ans. Percent of α-particles deflected at more than 50°
= 1% of α-particles.
Percent of α-particles deflected at less than 50°
= 100 – 1 = 99%
Number of α-particles bombarded = 1 mole
= 6.022×10^{23} particles
Number of particles that deflected at an angle less than 50°
$= \frac{99}{100} \times 6.022 \times 10^{23}$
$= \frac{596.178}{100} \times 10^{23}$
$= 5.96 \times 10^{23}$

BOARD CORNER

Very Short Answer Type Questions

Ⓡ Q. 1. Write the charge and mass of an electron. 1 [SA-II, 2017]

Ans. Charge of electron = -1.602×10^{-19}c
Mass of electron = 9.109×10^{-31} kg ½ + ½

Ⓡ Q. 2. Write down the electronic configuration of oxygen atom. Show how many valence electrons does it have? (Atomic number of oxygen is 8) 1 [SA-II, 2017]

Ans. 2, 6
$_8O$ = 2, 6
Number of valence electrons = 6 ½ + ½

Short Answer Type Questions

Ⓚ Q. 1. Define valency ? Find valency of oxygen and silicon? [OS] 2 [KVS 2019]

Ans. Valency can be defined as combining capacity of an atom.
Valency of oxygen :
Oxygen : 2, 6
Valency = 8-6 = 2
Valency of silicon :
Silicon : 2, 8, 4
The number of valence electrons is 4, So, the valency is 4.

Ⓚ Q. 2. Given that the percentage abundance of the isotope $_{10}Ne^{20}$ is 90% and that of isotope $_{10}Ne^{20}$ is 10%. Calculate the average atomic mass of N. [OS] 2 [KVS 2019]

Ans. Average atomic mass is given by :
$= 20 \times \frac{90}{100} + 22 \times \frac{10}{100}$
= (18 + 2.2)u
= 20.2u 2

Commonly Made Error
- Calculation error is commonly seen. Many students place incorrect values while calculating average atomic mass.

Answering Tip
- Students should be thorough with valency and electroinc configuration of elements.

Short Answer Type Questions

Ⓤ Q. 1. (a) If an atom one electron and one proton, state the charge on the atom. Justify your answer.
(b) If Z = 3, what would be the valency of the element? Also name the element. [SA-II, 2017]

Ans. **(a)** No charge because one electron has 1u negative charge and one proton has 1u positive charge which cancel each other making it electronically neutral.
(b) Z = 3 = 2, 1, valency = 1
The element with atomic number 3 is Lithium.
[CBSE Marking Scheme 2017]

Ⓡ Q. 2. (a) Why did Rutherford choose gold and not any other lighter element (such as aluminium) for his experiment? Explain your answer giving two reasons.
(b) Write the name and symbol of the particle choosen by Rutherford for bombardment against the gold foil in his experiment. 3 [SA-II, 2017]

Ans. **(a)** Gold is a heavy atom with high mass number. A lighter metal (such as Aluminium) cannot be used because on being hit by fast moving α-particle, the atom of the lighter element will be simply pushed forward and no scattering would occur. Also, gold is highly malleable and a very thin gold foil can be obtained.
(b) Rutherford choose α-particle for bombardment against the gold foil in his experiment. Symbol α-represents Helium particles $_2He^4$. 3

Long Answer Type Questions

Ⓡ Q. 1. (a) Compare all the proposed models of an atom. 5 [KVS 2018]

Ans. Thomson's Model of an Atom :
(i) An atom consists of a sphere of positively charge with negatively charged electrons embedded in it.
(ii) The positive and the negative charges in an atom are equal in magnitude due to which an atom is electrically neutral.
Rutherford's Model of an Atom :
(i) There is a positively charged centre in an atom called the nucleus. Nearly the whole mass of an atom resides in the nucleus.

(ii) The electrons revolve around the nucleus in circular path.

(iii) The size of the nucleus is very small compared to the size of an atom.

Bohr's Model of an Atom :

(i) An atom consists of a positively charged centre called the nucleus where the whole mass of the atom is concentrated.

(ii) Electrons revolve in orbits with discrete energy levels.

(iii) Under normal conditions, the energy of the 1^{st} energy level will be lowest, say E_1. Other orbits, 2^{nd}, 3^{rd} ..... will have energies E_2, E_3 .....

(iv) As long as an electron revolves in the same orbit, it does not radiate energy levels.

(v) When we supply energy to an electron, it can go to higher energy levels.

(vi) When an electron falls from a higher energy level to a lower energy level, the difference in energy between the two energy levels is radiated.

(vii) Since each atom has its specific energy levels, it can emit radiations of specific wavelengths or energy which leads to characteristic spectra of different atoms.

Ⓡ Q. 2.(i) Summarize the rules for writing of distribution of electrons in various shells for first eighteen elements.

(ii) Explain with examples.

(a) Isotopes. (b) Isobars. 5 [KVS-2018]

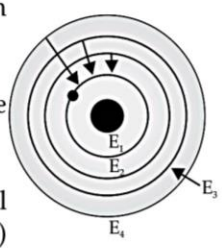
Ans. (a) Bohr and Bury Scheme for distribution of electrons in different energy levels :

(i) The maximum number of electrons in an energy level is equal to $2n^2$ wher 'n' is the energy level.

1^{st} energy level can have $2n^2 = 2 \times 1^2 = 2$ electrons.

2^{nd} energy level can have $2 \times 2^2 = 8$ electrons.

3^{rd} energy level can have $2 \times 3^2 = 18$ electrons.



(ii) The last energy level (outermost energy level) cannot have more than 8 electrons.

(iii) The last but one shell (penultimate shell) cannot have more than 18 electrons.

(iv) The last but second shell (anti-penultimate shell) cannot have more than 32 electrons.

(b) Isotopes : Elements having same atomic number but different atomic masses are called isotopes.

Example : Calcium $\left({}_{20}Ca^{40}\right)$ and $\left({}_{18}Ar^{40}\right)$ Argon

Ⓚ Q. 3. Write postulates of Thomson's model of an atom with diagram. 5 [KVS 2019]

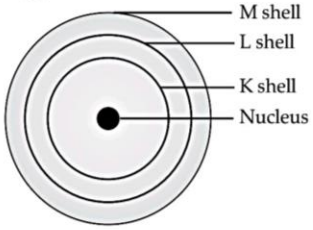
Ans. Postulates of Thomson's model of an atom :

(i) An atom is uniform sphere of positive charges (due to presence of protons) as well as negative charges (due to presence of electrons) which are embedded in it. This model is called 'Watermelon or plum pudding model'.

(ii) An atom, as a whole, is electrically neutral because the negative and positive charges are equal in magnitude.

Ⓚ Q. 4. Describe Bohr's model of atom. Draw model of an atom with three shell. 5 [KVS, 2019]

Ans. According to Bohr's model of atom, electrons revolve the nucleus in a limited number of orbits called discrete orbits. While revolving in these orbits, the electrons does not radiate. Energy of an electron remains constant as long as it stays in a given orbit. Electrons present in different orbits have different energies. When an electron jumps from higher energy level to lower, energy is released whereas energy is absorbed, when an electron jumps from lower to higher energy level.



Commonly Made Error

- Students get confuse with Bohr Bury and Rutherford model.

Answering Tip

- Students should know well about KLMN labelling of shells or orbits.