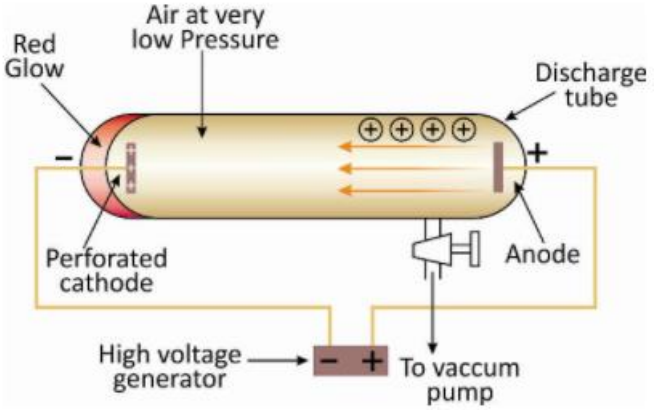
Chapter – 4 Structure of the Atom

Class 9 Science NCERT Textbook – Page No. 47

Question 1. What are canal rays?

Answer: Canal rays are anode rays, or positively charged rays which move towards the negative electrode or cathode rays in a discharge tube on passing high voltage of electricity through a gas at very low pressure.



Generation of Canal Rays

Question 2. If an atom contains one electron and one proton, will it carry any charge or not?

Answer:

- An electron has one unit of negative charge and a proton has one unit of positive charge.
- If an atom has one electron and one proton, the net charge on the atom is zero.
- So, an atom is neutral in nature.

Class 9 Science NCERT Textbook – Page No. 49

Question 1. On the basis of Thomson's model of an atom, explain how the atom is neutral as a whole.

Answer:

- In Thomson's model of an Atom –

i. An atom is a sphere of positive charge with negatively charged electrons surrounding it, like seeds in a watermelon.

ii. The total negative charge of electrons is equal to that of positive charge of an atom.
iii. The equal and opposite charges balance each other so an atom is electrically neutral.

Question 2. On the basis of Rutherford's model of an atom, which sub-atomic particle is present in the nucleus of an atom?

Answer:

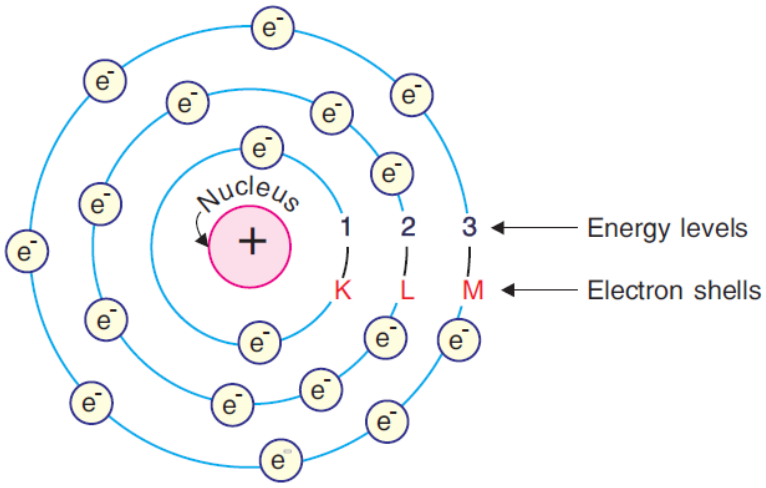
- In Rutherford's model of an atom –

i. An atom has positively charged nucleus.
ii. Protons consist of positive charges.
iii. Proton is sub-atomic particle in the nucleus .

Question 3. Draw a sketch of Bohr's model of an atom with three shells.

Answer:

Bohr's model of atom with three electron shells: -



- In Bohr's model of an atom:

i. The positively charged nucleus is at the centre.
ii. The negatively charged electrons move around the nucleus in various energy level.
iii. The energy levels are ($n = 1, 2, 3, 4$) or electron shells (K, L, M, N).

Question 4. What do you think would be the observation if the $\propto -particles$ scattering experiment is carried out using a foil of a metal other than gold?

Answer:

i) If foil of a heavy metal like platinum, is used, then the observations in the $\propto -particles$ scattering experiment is same as in the gold foil experiment.

ii) If foil of a light metal like lithium, with very light nucleus is used, then the fast-moving heavy $\propto -particles$ will push the light nucleus.

Class 9 Science NCERT Textbook – Page No. 49

Question 1. Name the three sub-atomic particles of an atom?

Answer:

The three sub-atomic particles of an atom are:

i. Electron (negatively charged particles).
ii. Proton (positively charged particles).
iii. Neutron (no charge particles).

Question 2. Helium atom has an atomic mass of $4\,u$ and two protons in its nucleus. How many neutrons does it have?

Answer:

- The atomic mass is equal to the mass number of an atom.
- The helium atom has an atomic mass of $4\,u$, so, the mass number of helium atom is 4.
- The number of protons in the helium nucleus is 2.

$$Mass\ number = Number\ of\ protons + Number\ of\ neutrons$$

$$4 = 2 + Number\ of\ neutrons$$

$$Number\ of\ neutrons = 4 - 2$$

$$Number\ of\ neutrons = 2$$

- So, the helium atom has $2\ neutrons$.

Class 9 Science NCERT Textbook – Page No. 50

Question 1. Write the distribution of electrons in carbon and sodium atoms.

Answer:

a) Arrangement of electrons in Carbon atoms –

i. The atomic number of carbon atom $= 6$.
ii. Atom of carbon has $6\ electrons$.
iii. Two electrons will occupy the first electron shell, the $K\ shell$.
iv. Remaining $4\ electrons$ will occupy the second electron shell, the $L\ shell$.
v. So, the electron arrangement in a carbon atom will be:

K	L
2	**4**

b) Arrangement of electrons in Sodium atoms –

i. The atomic number of sodium atom $= 11$.
ii. So, atom of sodium has $11\ electrons$.
iii. Out of $11\ electrons$, the first two electrons are in $K\ shell$.
iv. Next $8\ electrons$ are in $L\ shell$, and remaining $1\ electron$ is in $M\ shell$.
v. So, the electron distribution in a sodium atom will be:

K	L	M
2	**8**	**1**

Question 2. If K and L shells of an atom are full, then what would be the total number of electrons in the atom?

Answer:

- $K\ shell$ has $2\ electrons$ and $L\ shell$ has $8\ electrons$.
- So, in K and L shell of an atom, a total of $2 + 8 = 10$ electrons are present.

Question 3. How will you find the valency of chlorine, sulphur and magnesium?

Answer:

i. **Valency of chlorine.** The atomic number of chlorine is 17. The chlorine atom has $17\ electrons$, so its electron configuration is

K	L	M
2	**8**	**7**

A chlorine atom has $7\ electrons$ in ($M\ shell$). A chlorine atom accepts one more electron to attain the inert gas electron configuration of eight valence electrons, so the valency of chlorine is - 1.

ii. **Valency of sulphur.** The atomic number of sulphur is 16. The sulphur atom has $16\ electrons$, so its electron configuration is

K	L	M
2	**8**	**6**

A sulphur atom accepts 2 more electrons to attain the inert gas electronic configuration of eight valence electrons, so the valency of sulphur is -2.

iii. **Valency of magnesium.** The atomic number of magnesium is 12. The magnesium atom has $12\ electrons$, so its electron configuration is

K	L	M
2	**8**	**2**

A magnesium atom has $2\ electrons$ in $M\ shell$. A magnesium atom can lose its two outermost electrons to attain the inert gas electron configuration, so the valency of magnesium is +2.

Class 9 Science NCERT Textbook – Page No. 52

Question 1. 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 atomic?
ii) What is the charge on the atom?

Answer:

i. Atomic number is equal to the number of protons. This atom contains eight protons, so the atomic number is 8.
ii. Atom contains an equal number of positively charged protons and negatively charged electrons, that is 8 each, so the charge on this atom is zero.

Q2. With the help of Table given below, find out the mass number of oxygen and sulphur atoms:

Name of element	Symbol	Atomic number	Number of protons	Number of neutrons	Number of electrons
Oxygen	O	8	8	8	8
Sulphur	S	16	16	16	16

Answer:

i. $$Mass\ number\ of\ oxygen = Number\ of\ protons + Number\ of\ neutrons$$
$$= 8 + 8$$
$$= 16$$
$$Mass\ number\ of\ oxygen = 16$$

ii. $$Mass\ number\ of\ sulphur = Number\ of\ protons + Number\ of\ neutrons$$
$$= 16 + 16$$
$$= 32$$
$$Mass\ number\ of\ sulphur = 32$$

Class 9 Science NCERT Textbook – Page no. 53

Q1. For the symbols H, D and T tabulate three sub-atomic particles found in each of them.

Answer:

- H, D, T are the three isotopes of hydrogen having the same atomic number one and different mass numbers of 1, 2 and 3 respectively.
- The symbol H stands for Hydrogen of mass number one.
- The symbol D stands for Deuterium, a is heavy hydrogen of mass number 2.
- The symbol T stands for Tritium, a is very heavy hydrogen of mass number 3.
- Electrons, protons and neutrons in the three isotopes of hydrogen are as follows:

Isotope	*Symbol*	*Mass number*	*Number of electrons*	*Number of protons*	*Number of neutrons*
Hydrogen	H	1	1	1	0
Deuterium	D	2	1	1	1
Tritium	T	3	1	1	2

Q2. Write the electronic configuration of any one pair of isotopes and isobars.

Answer:

a) Isotopes of chlorine are $^{35}_{17}Cl$ and $^{37}_{17}Cl$. The atomic number of both the isotopes is the same, that is 17.
So, the electronic configuration of both isotopes is 2, 8, 7.

b) The two isobars are $^{40}_{18}Ar$ and $^{40}_{20}Ca$. The atomic number of argon (Ar) is 18, so its electronic configuration is 2, 8, 8. The atomic number of calcium (Ca) is 20. So, its electronic configuration is 2, 8, 8, 2.

Class 9 Science NCERT Textbook Exercise – Page No. 54

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

Answer:

S/No.	Sub-atomic particle	Relative mass	Relative charge	Location in the atom
1.	Proton	$1\ u$	$+1$	In the nucleus
2.	Neutron	$1\ u$	0	In the nucleus
3.	Electron	$\frac{1}{1840}\ u$	-1	Outside nucleus

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

Answer:

- J.J Thomson's model of an atom was unable to elucidate the outcome of $\alpha - particle$ scattering experiment which was done by Rutherford model of an atom.
- J.J Thomson model of an atom could not elucidate movement of the positively charged $\alpha - particle$ passing straight into the gold foil, few $\alpha - particle$ were deflected by small and large angles, but a very few $\alpha - particle$ completely bounced back on hitting the gold foil and return on their path.
- J.J Thomson's model of an atom was hypothetical, it did not have experimental evidence to prove it, unlike Rutherford's model of an atom.

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

Answer:

The limitations of Rutherford's model of an atom:

i. It was unable to explain the stability of an atom.
ii. As the particle in a circular orbit undergo acceleration, it will radiate energy.
iii. The revolving electrons lose energy and fall into the nucleus.

Question 4. Describe Bohr's model of the atom?

Answer:

The Bohr's model of an atom:

1. An atom is made of three sub-atomic particles: electrons, protons and neutrons.
2. The protons and neutrons are in a small nucleus at the centre of the atom.
3. The electrons revolve round the nucleus in fixed circular paths called energy levels or shells K, L, M, N, O and P.
4. There is definite number of electrons in each energy level or shell.
5. Each energy level/shell has a fixed amount of energy.
6. There is no change in the energy of electrons if it revolves in the same energy level so atom remains stable.

Question 5. Compare all the proposed models of an atom.

Answer:

S/No.	Thomson's model	Rutherford's model	Bohr's model
1.	An atom consists of positively charged protons and electrons surrounded in it.	An atom consists of a positively charged nucleus at its centre with negatively charge electrons revolving around them.	An atom is made up of electrons, protons and neutrons.
2.	The atom is electrically neutral, as the total number of positive charges is equal to number of negative charges.	The atom has electrostatic attraction between the positively charged nucleus and the negatively charged electrons.	The atom is electrically neutral due to the presence of equal number of negative electrons and positive protons.
3.		The total mass of an atom is in the nucleus.	A nucleus at the centre of an atom consists of protons and neutrons, so nucleus is positively charged.
4.		Most of the atom has empty space.	The electrons revolve round the nucleus in a circular path called energy levels/ shells

			(represented by 1, 2, 3, 4, 5 and 6 or K, L, M, N, O and P).

Q6. Summarise the rules for writing of distribution of electrons in various shells for the first eighteen elements.

Answer:

The number of electrons in different energy level is calculated by the formula $2n^2$.

a) For energy level (n = 1) or K shell:

$$2n^2 = 2 \times (1)^2 = 2 \times 1 = 2$$

b) For energy level (n = 2) or L shell:

$$2n^2 = 2 \times (2)^2 = 2 \times 4 = 8$$

c) For energy level (n = 3) or M shell

$$2n^2 = 2 \times (3)^2 = 2 \times 9 = 18$$

d) For energy level (n = 4) or N shell

$$2n^2 = 2 \times (4)^2 = 2 \times 16 = 32$$

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

Answer:

Valency of an element is the number of electrons lost, gained or shared by one atom of any element to attain inert gas electron configuration.

Example:

i. Valency of Silicon.

The atomic number of silicon is 14, it has 14 electrons in its atom.
The configuration of silicon atom will be given as

K	***L***	***M***
2	8	4

- So, silicon atom has four electrons in its outermost M shell.
- Silicon atom can neither lose four electrons nor gain four electrons to attain octet because of energy difference.
- A silicon atom shares four electrons to get the inert gas electronic configuration.
- So, the valency of silicon is 4.

ii. Valency of Oxygen.

The atomic number of oxygens is eight, as it has 8 electrons in its atom.

The configuration representation of oxygen atom is

K	***L***
2	6

- So, the oxygen has six electrons in the L shell.
- An oxygen atom with 6 outermost electrons take 2 electrons from some other atom to get inert gas electron configuration of $6 + 2 = 8$.
- So, the valency of oxygen is- 2.

Question 8. Explain with examples

i. Atomic number.
ii. Mass number.
iii. Isotopes
iv. Isobars

Give any two uses of isotopes.

Answer:

i) **Atomic number:** The number of protons in atom of an element is known as atomic number.

For example, one atom of sodium element has 11 protons, so the atomic number of sodium will be 11.

One atom of carbon element has 6 protons, so the atomic number of carbon element is 6.

iii. **Mass number:** it is the total number of protons and neutrons present in an atom of an elements.

For example, one atom of sodium contains 11 proton and 12 neutrons, so the mass number of sodium is $11 + 12 = 23$.
Carbon atom has 6 protons and 6 neutrons, so the mass number of carbons is $6 + 6 = 12$

iii. **Isotopes:** Atoms of the same element with the same atomic number but different mass numbers because they have same number of protons and electrons. Isotopes have different number of neutrons, so they have different mass number.

For example, Chlorine atoms have 17 protons, so its atomic number is 17. Chlorine atoms have 18 neutrons and other chlorine atoms contain 20 neutrons.

$$\mathbf{{}^{35}_{17}Cl \text{ and } {}^{37}_{17}Cl}$$

iv. **Isobars:** Atoms of different elements having different atomic numbers and same mass number. Isobars have different number of protons but the total number of nucleons in them is same.

For example, Argon and Calcium have different atomic numbers of 18 and 20 respectively but they have same mass number 40.

$$\mathbf{{}^{40}_{18}Ar \text{ and } {}^{40}_{20}Ca}$$

Question 9. Na^+ has completely filled K and L shell.

Answer:

A sodium ion, Na^+ has 10 electrons. The maximum electron in K shell is 2 and in L shell is 8 electrons.

Thus, the maximum number of electrons in K and L shells is

$$\mathbf{2 + 8 = 10\ electrons}$$

A sodium ion, Na^+ has completely filled K and L shell, as it has 10 electrons in K and L shell.

Question 10. 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 mass of bromine atom.

Answer:

i. The mass of $^{79}_{35}Br$ is 79 u (49.7%) since the upper digit in an isotope is its mass.
ii. The mass of $^{81}_{35}Br$ is 81 u (50.3%) since the upper digit in the symbol of an isotope is its mass.

Average atomic mass of bromine $= 79 \times \frac{49.7}{100} + 81 \times \frac{50.3}{100}$

$$= \frac{3926.3}{100} + \frac{4074.3}{100}$$

$$= 39.263 + 40.743$$

$$= 80.006$$

$$= 80\,u$$

$$So, the\ average\ atomic\ mass\ of\ bromine\ is\ 80\,u.$$

Q11. The average atomic mass of a sample of an element X is 16.2 u. What are the percentages of isotopes $^{16}_{8}X$ and $^{18}_{8}X$ in the sample?

Answer:

i. The mass of $^{16}_{8}X$ isotope is 16 u. Suppose its percentage in sample is $y\%$.
ii. The mass of $^{18}_{8}X$ isotope is 18 u. So, its percentage in sample will be $(100 - x)\%$.

Average atomic mass of $X = 16 \times \frac{x}{100} + 18 \times \frac{(100-x)}{100}$

As the average atomic mass of X is 16.2 u. So,

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

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

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

$$2x = 1800 - 2x$$

$$2x = 1800 - 1620$$

$$2x = 180$$

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

$$x = 90$$

Thus, the percentage of the isotope ${}^{16}_{8}X$ in the sample is 90%.

The percentage of the other isotope ${}^{18}_{8}X$ in the sample is (100 - 90) = 10%.

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

Answer:

- Z symbol is the atomic number of an element.
- $Z = 3$ shows that the atomic number of this element is 3.
- The atomic number 3 has the electronic configuration as:

K	L
2	1

- It shows that one electron is in the outermost shell (L shell).
- It means 1 atom of this element can give 1 electron to achieve the nearest inert gas electron of $\frac{K}{2}$ (Helium gas).
- So, we can say that this element has valency of 1.
- The element having atomic number 3 is lithium.

Question 13. Composition of the nuclei of two atomic species X and Y are given as under

	X	Y
$Protons$	6	6
$Neutrons$	6	8

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

Answer:

$$Mass\ number = Number\ of\ protons + Number\ of\ neutrons$$

Mass number of X = 6 + 6

= 12

Mass number of Y = 6 + 8

= 14

So, the mass number of X is 12 and that of Y is 14.

Thus:

- X contains 6 protons, so, the atomic number of X is 6.
- Y contains 6 protons, so, the atomic number of Y is 6.
- Since, X and Y have the same atomic number but different mass numbers, so they are a pair of isotopes.
- Atomic number 6 is of carbon element. So, X and Y represent carbon element.

Question 14. For the following statement, 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 $\frac{1}{2000}$ times that of proton.
d) An isotope of iodine is used for making tincture iodine, which is used as a medicine.

Answer:

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

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

a) Atomic nucleus.
b) Electron.
c) Proton.
d) Neutron.

Answer: a) Atomic nucleus.

Question 16. Isotopes of an element have:

a) **The same physical properties.**
b) **Different chemical properties.**
c) **Different number of neutrons.**
d) **Different atomic numbers.**

Answer: c) Different number of neutrons.

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

a) **16**
b) **8**
c) **17**
d) **18**

Answer: b) 8

Chlorine Cl has 7 valence electrons. A chloride ion is formed by the gain of 1 more electron to a chlorine atom. The number of valence electrons in a chloride ion Cl^- is 7 + 1 = 8.

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

a) **2,8**
b) **8,2,1**
c) **2,1,8**
d) **2,8,1**

Answer: d) 2,8,1

Question 19. Complete the following table:

Atomic number	Mass number	Number of neutrons	Number of protons	Number of electrons	Name of the atomic species
9	—	10	—	—	—
16	32	—	—	—	Sulphur
—	24	—	12	—	—
—	2	—	1	—	—
—	1	0	1	0	—

Answer:

a) First row:

i) The atomic number is 9, so number of protons is 9 , number of electrons is also 9 and number of neutron is 10.
ii) Mass number = number of protons + number of neutrons, mass number = 9 +10 = 19.
iii) Fluorine has atomic number = 9.

b) Second row:

i) The atomic number is 16, so the number of protons is 16, the number of electrons is also 16 .
ii) Number of neutrons = mass number – number of protons, number of neutrons = 32 – 16 = 16.

c) Third row:

i) The number of protons is 12, so atomic number is 12 and the number of electrons is also 12.
ii) Number of neutrons = mass number – number of protons, number of neutrons = 24 – 12 = 12.
iii) Magnesium has the atomic number = 12.

d) Fourth row:

i) The number of protons is 1, so atomic number is 1 and the number of electrons is also 1.
ii) Number of neutrons = mass number – number of protons, number of neutrons = 2 -1 = 1.
iii) The atomic number 1 and mass number 2 is heavy Hydrogen or Deuterium.

e) Fifth row:

i) The number of protons is 1, so the atomic number is also 1.
ii) The atomic number 1 and mass number 1 is Hydrogen or Protium.

The table can be completed by substituting the above calculated values

Atomic	Mass	Number of	Number of	Number of	Name of

number	number	neutrons	protons	electrons	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	Deuterium
1	1	0	1	0	Protium (Hydrogen)