

Chapter 4: Structure of the Atom Science

1. What are canal rays?

Answer

Canal rays are positively charged radiations that can pass through perforated cathode plate. These rays consist of positively charged particles known as protons.

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

Answer

An electron is a negatively charged particle, whereas a proton is a positively 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.

Page No: 49

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

Answer

As per Thomson's model of the atom, an atom consists both negative and positive charges which are equal in number and magnitude. So, they balance each other as a result of which atom as a whole is electrically neutral.

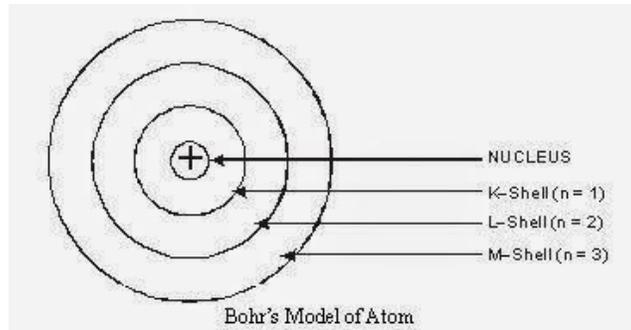
2. On the basis of Rutherford's model of an atom, which subatomic particle is present in the nucleus of an atom?

Answer

On the basis of Rutherford's model of an atom, protons are present in the nucleus of an atom.

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

Answer



Bohr's Model of an atom with three shells

4. 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?

Answer

If α -particle scattering experiment is carried out using a foil of any metal as thin as gold foil used by Rutherford, there would be no change in observations. But since other metals are not so malleable so, such a thin foil is difficult to obtain. If we use a thick foil, then more α -particles would bounce back and no idea about the location of positive mass in the atom would be available with such a certainty.

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

Answer

The three sub-atomic particles of an atom are:

- (i) Protons
- (ii) Electrons, and
- (iii) Neutrons

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

Answer

Number of neutrons = Atomic mass - Number of protons
Therefore, the number of neutrons in the atom = $4 - 2 = 2$

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

Answer

► 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

Or, we can write the distribution of electrons in a carbon atom as 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

Or, we can write distribution of electrons in a sodium atom as 2, 8, 1.

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

Answer

The maximum capacity of K shell is 2 electrons and L shell can accommodate maximum 8 electrons in it. Therefore, there will be ten electrons in the atom.

Page No: 52

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

Answer

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 in the outermost shell. On the other hand, 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, sulphur, and magnesium atoms are 2, 8, 7; 2, 8, 6 and 2, 8, 2 respectively.

Therefore, the number of electrons in the outer most shell of chlorine, sulphur, and magnesium atoms are 7, 6, and 2 respectively.

► Thus, the valency of chlorine = $8 - 7 = 1$

► The valency of sulphur = $8 - 6 = 2$

► The valency of magnesium = 2

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 atom and (ii) what is the charge on the atom?

Answer

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

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

2. With the help of Table 4.1, find out the mass number of oxygen and sulphur atom.

Answer

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

Page No: 53

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

Answer

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

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

Answer

$^{12}\text{C}_6$ and $^{14}\text{C}_6$ are isotopes, have the same electronic configuration as (2, 4)
 $^{22}\text{Ne}_{10}$ and $^{22}\text{Ne}_{11}$ are isobars. They have different electronic configuration as given below:
 $^{22}\text{Ne}_{10} - 2, 8$
 $^{22}\text{Ne}_{11} - 2, 8, 1$

Page No: 54

Excercise

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

Answer

Particle	Nature of Charge	Mass	Location
Electron	Electrons are negatively charged.	9×10^{-31} kg	Extra nuclear part distributed in different shell or orbits.
Proton	Protons are positively charged.	1.672×10^{-27} kg (1 μ) (approx. 2000 times that of the electron)	Nucleus
Neutron	Neutrons are neutral.	Equal to mass of proton	Nucleus

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

Answer

The limitations of J.J. Thomson's model of the atom are:

- It could not explain the result of scattering experiment performed by Rutherford.
- It did not have any experimental support.

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

Answer

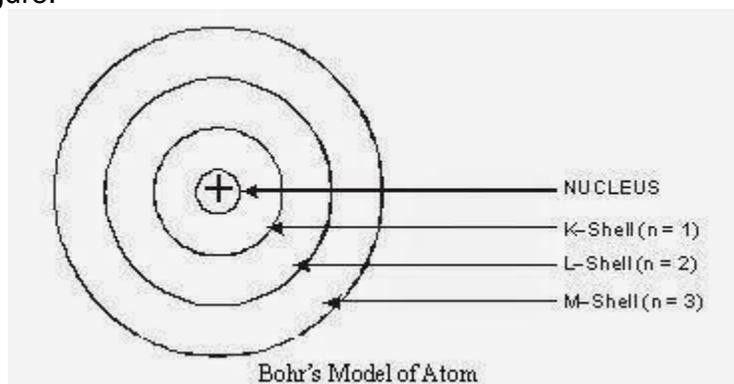
The limitations of Rutherford's model of the atom are

- It failed to explain the stability of an atom.
- It doesn't explain the spectrum of hydrogen and other atoms.

4. Describe Bohr's model of the atom.

Answer

- The atom consists of a small positively charged nucleus at its center.
- The whole mass of the atom is concentrated at the nucleus and the volume of the nucleus is much smaller than the volume of the atom.
- All the protons and neutrons of the atom are contained in the nucleus.
- Only certain orbits known as discrete orbits of electrons are allowed inside the atom.
- While revolving in these discrete orbits, electrons do not radiate energy. These orbits or shells are represented by the letters K, L, M, N etc. or the numbers, $n = 1, 2, 3, 4, \dots$ as shown in the below figure.



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

Answer

Thomson's model	Rutherford's model	Bohr's model
<p>→ An atom consists of a positively charged sphere and the electrons are embedded in it.</p> <p>→ The negative and positive charges are equal in magnitude. As a result the atom is electrically neutral.</p>	<p>→ An atom consists of a positively charged center in the atom called the nucleus. The mass of the atom is contributed mainly by the nucleus.</p> <p>→ The size of the nucleus is very small as compared to the size of the atom.</p> <p>→ The electrons revolve around the nucleus in well-defined orbits.</p>	<p>→ Bohr agreed with almost all points as said by Rutherford except regarding the revolution of electrons for which he added that there are only certain orbits known as discrete orbits inside the atom in which electrons revolve around the nucleus.</p> <p>→ While revolving in its discrete orbits the electrons do not radiate energy.</p>

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

Answer

The rules for writing of the distribution of electrons in various shells for the first eighteen elements are given below.

→ If n gives the number of orbit or energy level, then $2n^2$ gives the maximum number of electrons possible in a given orbit or energy level. Thus,

First orbit or K-shell will have 2 electrons,

Second orbit or L-shell will have 8 electrons,

Third orbit or M-shell will have 18 electrons.

→ If it is the outermost orbit, then it should have not more than 8 electrons.

→ There should be step-wise filling of electrons in different orbits, i.e., electrons are not accompanied in a given orbit if the earlier orbits or shells are incompletely filled.

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

Answer

The valency of an element is the combining capacity of that element. The valency of an element is determined by the number of valence electrons present in the atom of that element. → Valency of Silicon: It has electronic configuration: 2,8,4

Thus, the valency of silicon is 4 as these electrons can be shared with others to complete

octet.

→ Valency of Oxygen: It has electronic configuration: 2,6

Thus, the valency of oxygen is 2 as it will gain 2 electrons to complete its octet.

Page No: 55

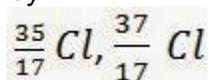
8. Explain with examples (i) Atomic number, (ii) Mass number, (iii) Isotopes and (iv) Isobars. Give any two uses of isotopes.

Answer

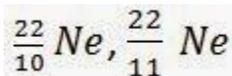
(i) Atomic number: The atomic number of an element is the total number of protons present in the atom of that element. For example, nitrogen has 7 protons in its atom. Thus, the atomic number of nitrogen is 7.

(ii) Mass number: The mass number of an element is the sum of the number of protons and neutrons present in the atom of that element. For example, the atom of boron has 5 protons and 6 neutrons. So, the mass number of boron is $5 + 6 = 11$.

(iii) Isotopes: These are atoms of the same element having the same atomic number, but different mass numbers. For example, chlorine has two isotopes with atomic number 17 but mass numbers 35 and 37 represented by



(iv) Isobars: These are atoms having the same mass number, but different atomic numbers i.e., isobars are atoms of different elements having the same mass number. For example, Ne has atomic number 10 and sodium has atomic number 11 but both of them have mass numbers as 22 represented by -



Two uses of isotopes:

→ One isotope of uranium is used as a fuel in nuclear reactors.

→ One isotope of cobalt is used in the treatment of cancer.

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

Answer

The atomic number of sodium is 11. So, neutral sodium atom has 11 electrons and its electronic configuration is 2, 8, 1. But Na^+ has 10 electrons. Out of 10, K-shell contains 2 and L-shell 8 electrons respectively. Thus, Na^+ has completely filled K and L shells.

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

Answer

It is given that two isotopes of bromine are $79 / {}_{35}\text{Br}$ (49.7%) and $81 / {}_{35}\text{Br}$ (50.3%). Then, the average atomic mass of bromine atom is given by:

$$\begin{aligned} & 79 \times \frac{49.7}{100} + 81 \times \frac{50.3}{100} \\ &= \frac{3926.3}{100} + \frac{4074.3}{100} \\ &= \frac{8000.6}{100} \\ &= 80.006 \text{ u} \end{aligned}$$

11. The average atomic mass of a sample of an element X is 16.2 u. What are the percentages of isotopes $16 / {}_8\text{X}$ and $18 / {}_8\text{X}$ in the sample?

Answer

It is given that the average atomic mass of the sample of element X is 16.2 u.

Let the percentage of isotope $^{18}_8\text{X}$ be $y\%$. Thus, the percentage of isotope $^{16}_8\text{X}$ will be $(100 - y)\%$.

Therefore,

$$18 \times \frac{y}{100} + 16 \times \frac{(100-y)}{100} = 16.2$$
$$\frac{18y}{100} + \frac{16(100-y)}{100} = 16.2$$
$$\frac{18y + 1600 - 16y}{100} = 16.2$$

$$18y + 1600 - 16y = 1620$$

$$2y + 1600 = 1620$$

$$2y = 1620 - 1600$$

$$y = 10$$

Therefore, the percentage of isotope $^{18}_8\text{X}$ is 10%.

And, the percentage of isotope $^{16}_8\text{X}$ is $(100 - 10)\% = 90\%$.

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

Answer

By $Z = 3$, we mean that the atomic number of the element is 3. Its electronic configuration is 2, 1. Hence, the valency of the element is 1 (since the outermost shell has only one electron).

Therefore, the element with $Z = 3$ is lithium.

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 of X = Number of protons + Number of neutrons
= 6 + 6
= 12

Mass number of Y = Number of protons + Number of neutrons
= 6 + 8
= 14

These two atomic species X and Y have the same atomic number, but different mass numbers. Hence, they are isotopes.

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.

▶ False

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

▶ False

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

▶ True

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

▶ False

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

(a) Atomic nucleus

(b) Electron

(c) Proton

(d) Neutron

▶ (a) Atomic nucleus

16. Isotopes of an element have

(a) the same physical properties

- (b) different chemical properties
- (c) different number of neutrons
- (d) different atomic numbers
- ▶ (c) different number of neutrons

17. Number of valence electrons in Cl⁻ ion are:

- (a) 16
- (b) 8
- (c) 17
- (d) 18
- ▶ (b) 8

Page No: 56

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
- ▶ (d) 2, 8, 1

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

Atomic number	Mass number	Number of Neutrons	Number of protons	Number of electrons	Name 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	Deuterium
1	1	0	1	0	Hydrogen ion