Atomic Structure

EXERCISE

Question 1.
State the main postulates of – Dalton's atomic theory. Explain how the modern atomic theory contradicted Dalton's atomic theory.

Answer:
(a) Dalton's Atomic Theory :
The main postulates of theory are :

1. Matter consists of small indivisible particles called – atoms i. e. Atom is the basic unit of matter.
2. Atoms of the same element are – alike in all respects i.e. atoms of hydrogen have same properties like mass, density and atoms of oxygen are alike in all respects.
3. Atoms of different elements are different from each other. i.e. atoms of hydrogen are different from atoms of oxygen.
4. Atom can neither be created nor destroyed.
5. Atoms combine with other atoms in simple whole number ratio forming compounds or molecules.

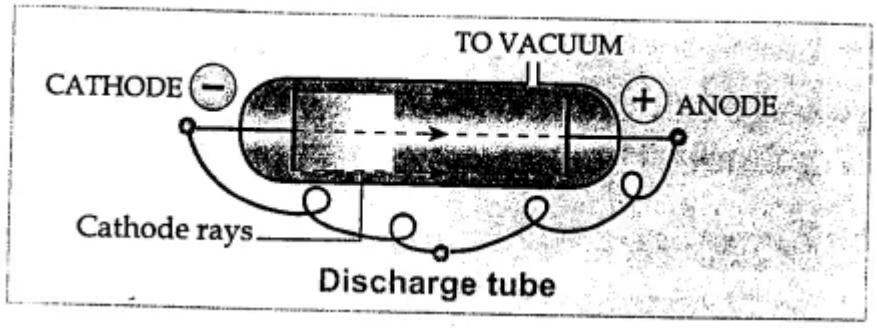
(b) Modern atomic theory contradicted Dalton Atomic Theory as :

1. Atom is no longer indivisible as atom has been divided and has sub – atomic particles
   (a) Protons
   (b) Neutrons
   (c) Electrons
2. Atoms of same element may have different properties

   i.e. Isotopes $^{1}_{1}H$, $^{2}_{1}H$, $^{3}_{1}H$
3. Atoms of different elements may have same properties i.e. isobars
4. Atoms combine with other atoms may not be in simple whole number ratio i.e. $C_{12}H_{22}O_{11}$ (Sugar).
5. Atom can be destroyed and converted into energy.

Question 2.
With reference to the discovery of the structure of an atom, explain in brief – William Crookes experiment for the discovery of cathode rays, followed by – J.J. Thomsons experiment pertaining to the constituents of the cathode rays. State which sub-atomic particle was discovered from his experiment.

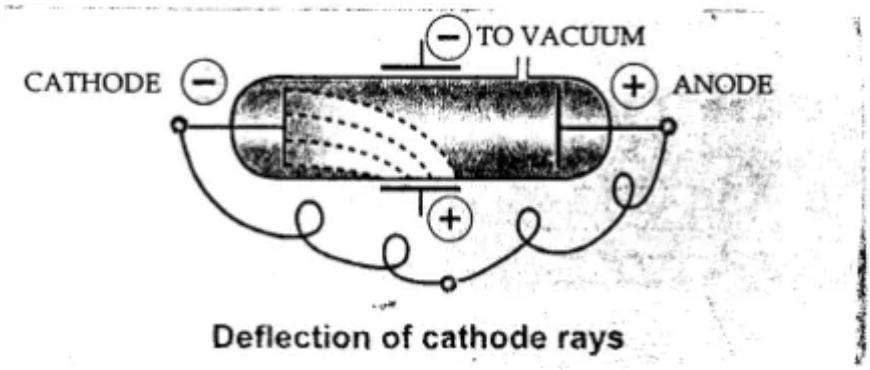
Answer:
Discovery of the three subatomic particles – electrons, protons and neutrons
Atom are built up of three sub-atomic particles – electrons, protons and neutrons.



Discovery of cathode rays leading to the discover of 'electrons'

- **Scientist** – William Crookes [1878]
- **Discovery** – The cathode rays

Experiment :



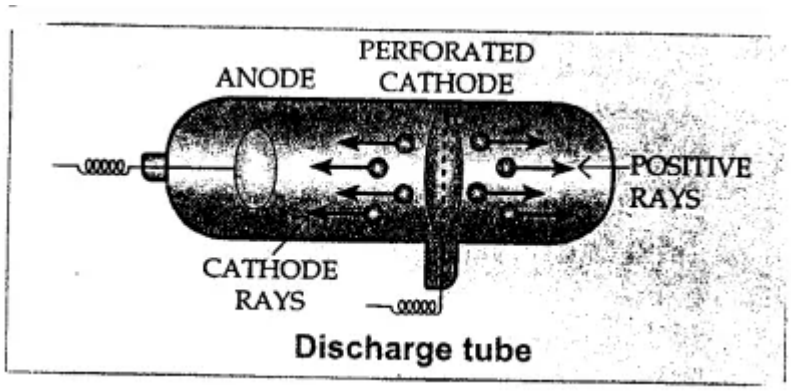
1. An electric discharge was passed through a tube containing a gas at low pressure.
2. Blue rays were emitted from the cathode [negative plate] – which were called cathode rays.

Question 3.
Explain in brief – Goldstein's experiment which led to the discovery of the proton and – Lod Rutherford's experiment which led to the discovery of the atomic nucleus.

Answer:
Discovery of – Protons

- **Discovery –** Constituent of positive rays i.e. particles that contain – protons.

Experiment :



- Goldstein used a modified cathode ray tube with a perforated cathode.
- He observed a new type of rays produced from the anode passing through the holes of the perforated cathode. These rays were called anode rays.

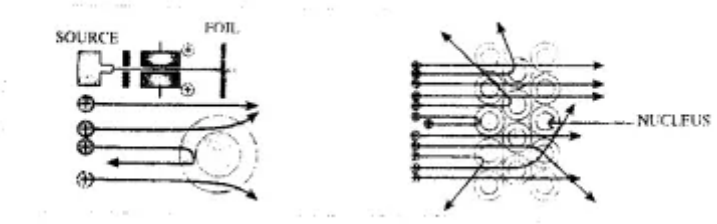
Conclusion :

- Anode rays or positive rays consist of positively charged particles now called – protons.
- The positive rays were affected by electric & magnetic fields but – in a direction opposite to that of cathode rays.
- Thus with the discovery of the positive particles – proton was initiated.

Discovery of – Atomic nucleus :

- Discovery – Study of the atomic model leading to the discovery of – atomic nucleus.

Experiment :



- Rutherford projected alpha particles towards a thin gold foil, – in the path of the rays.
- He saw that most of the alpha particles went straight through the foil, – but some were deflected slightly & some by large angles.

Conclusion :

- An atom on the whole is relatively empty but consists of a – concentrated positive mass in the centre, which lead to the deflection of the alpha particles.
- Thus the discovery of a central positive region – atomic nucleus was initiated.

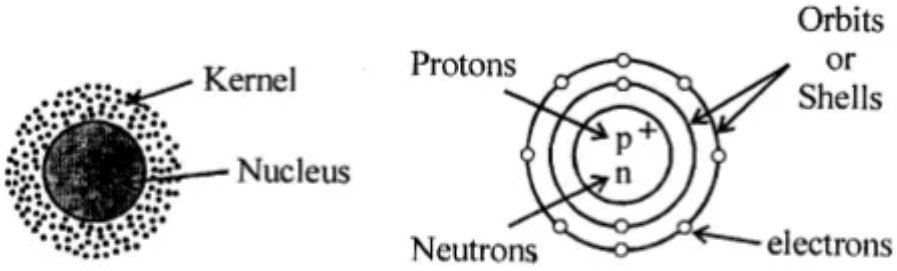
Question 4.
'Electrons revolve around the nucleus in fixed orbits or shells called energy levels'. State how these energy levels are represented.

Answer:

(a) Electrons revolve around the nucleus in – fixed 'orbits' called energy levels
(b) The energy levels 1, 2, 3… are represented by – integer 'n' or as K, L, M, N…
(c) Electrons rotate around the nucleus, in one or .more of the energy levels.

Question 5.
Draw a neat labelled diagram representing an atom. Name the three sub-atomic particles in the atom & represent them symbolically showing the mass & charge of each. State where the sub-atomic particles are present in the atom.

Answer:



Sub-atomic particles are :

a. electrons ${}_{-1}e$ – present in orbit around the nucleus

b. Proton ${}^{1}_{1}p$ – in nucleus

c. Neutrons ${}^{1}_{0}n$ – in nucleus

Question 6.
Define the term – 'atomic number' of an atom. If an atom 'A' has an atomic number of – eleven, state the number of protons & electrons it contains.

Answer:
Atomic number is the number of protons in the atom of an element. Since atom is electrically neutral i.e. is charge less, therefore
number of electrons = number of protons.
∴ It has 11 P and 11 electrons.
Atomic number z = p = e

Question 7.
Define the term – 'mass number ' of an atom. If an atom t 'B' has mass number 35 & atomic number 17, state the number of protons, electrons & neutrons it contains.

Answer:
Mass number of an element is equal to the sum of protons and neutrons in the nucleus of atom.
Mass number = Number of protons + Number of neutrons
A = p + n A = 35 atomic number p = 17
∴ 35 = 17 + n
∴ n = number of neutrons = 35 – 17 = 18
n = 18
But p = e
∴ e = p = 17
Number of electrons = e = 17

Question 8.
State why the atomic weight of an element is also termed – relative atomic mass.

Answer:

- **Atomic weight :** is mass of an atom, the number times it is heavier than an atom of hydrogen.
  Since carbon atom is 12 times heavier than an atom of hydrogen.
- **Relative mass :** is equal to the number of times an atom of an element is heavier than 1/12 the mass of an atom of carbon.
  Hence atomic weight of an element is also termed relative atomic mass as it is in comparison with mass of 1/12 th mass of a carbon atom.

Question 9.
State how electrons are distributed in an atom. Explain in brief the rules which govern their distribution.

Answer:
(a) Electrons revolve around the nucleus in imaginary paths called shells or orbits. Shells start from nucleus to outwards.

Rules : Maximum number of electrons in a shell is given by $2n^2$. Where n is the number of shell i.e. 1st shell can have maximum of 2 electrons.
$2n^2 = 2(1)^2 = 2 \times 1 = 2$
2nd shell can have maximum of 8 electrons
$2n^2 = 2(2)^2 = 2 \times 4 = 8$
3rd shell can have maximum of 18 electrons

$2n^2 = 2\ (3)^2 = 2 \times 9 = 18$ and so on….
(b) Outer most orbit cannot have more than 8 electrons and 18 in penultimate orbit.
(c) A new shell cannot start until previous is filled completely.

Question 10.
If an atom 'A' has atomic number 19 & mass number 39, state –

1. Its electronic configuration.
2. The number of valence electrons it possesses.

Answer:
Atom 'A' has mass number A = 39 and atomic number Z = 19 = p
∴ A = Z + n
A = p + n
39 = 19 + n
n = 39 – 19 = 20
But e = p = 19

1. A (K, L, M, N)
   19 = 2, 8, 8, 1
   There will be 2 electrons in K-shell or 1st shell
   8 electrons in 2nd shell or L-shell
   8 electrons in 3rd shell or M-shell
   1 electron in 4th shell or nth-shell
2. The number of valence electrons i.e. in outer most shell = 1 electron.

Question 11.
Draw the atomic diagrams of the following elements showing the distribution of – protons, neutrons & the electrons in the various shells of the atoms.

a. Carbon – $^{12}_{6}C$, **b. Oxygen – $^{16}_{8}O$**
c. Phosphorus – $^{31}_{15}P$, **d. Argon – $^{40}_{18}Ar$**
e. Calcium – $^{40}_{20}Ca$

[The upper number represents the – mass number & the lower number the – atomic number e.g. calcium – mass number = 40, atomic number = 20]

Answer:

a. Carbon – $^{12}_{6}C$

Mass number A = $p + n = 12$

$6 + n = 12$

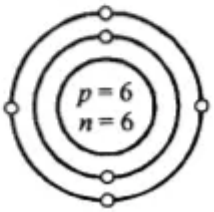
$\therefore \quad n = 12 - 6 = 6$

$e = p$ = Atomic number = 6

C

6 = 2, 4

(K, L)



b. Oxygen – $^{16}_{8}O$

Atomic number Z = $p = e = 8$

Mass number A = $p + n$

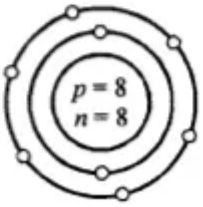
$16 = 8 + n$

$\therefore \quad n = 16 - 8 = 8$

O

8 = 2, 6

(K, L)



c. Phosphorus – $^{31}_{15}P$

Atomic number $Z = p = e = 15$

Mass number $A = p + n$

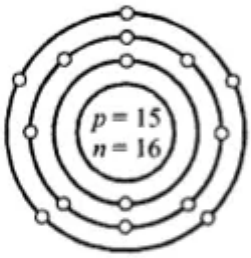
$31 = 15 + n$

$\therefore \quad n = 31 - 15 = 16$

P

15 = 2, 8, 5

(K, L, M)



d. Argon – $^{40}_{18}Ar$

Atomic number $Z = p = p = 18$

Mass number $A = p + n$

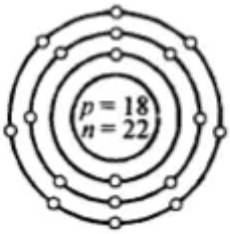
$40 = 18 + n$

$\therefore \quad n = 40 - 18 = 22$

Ar

15 = 2, 8, 8

(K, L, M)



e. Calcium – $^{40}_{20}Ca$

Atomic number $Z = p = e = 20$

Mass number $A = p + n$

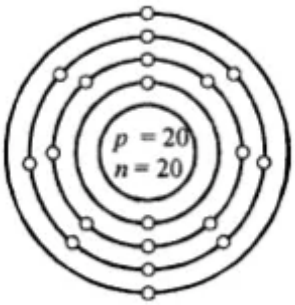
$40 = 20 + n$

$\therefore \quad n = 40 - 20 = 20$

Ca

15 = 2, 8, 8, 2

(K, L, M, N)



Question 12.
` Valency is the number of hydrogen atoms which can combine with [or displace] one atom of the element [or radical] forming a compound'. With reference to the above definition of valency, state the valency of chlorine in hydrogen chloride, giving reasons.

Answer:
Hydrogen chloride [HCl], one atom of chlorine has combined with one atom of hydrogen and also 1 atom of hydrogen can be replaced by metals like potassium, sodium. Hence valency of chlorine in one.

Question 13.
` Valency is also the number of electrons – donated or accepted by an atom so as to achieve stable electronic configuration of the nearest noble gas'. With reference to this definition –

(a) State what is meant by 'stable electronic configuration'.
(b) State why the valency of –

1. sodium, magnesium & aluminium is : +1, +2 & +3 respectively.
2. chlorine, oxygen & nitrogen is : -1, -2 & -3 respectively.

Answer:

(a) Stable electronic configuration means to have 2 electrons in the 1st [or K] outer most shell like He – [Duplet].

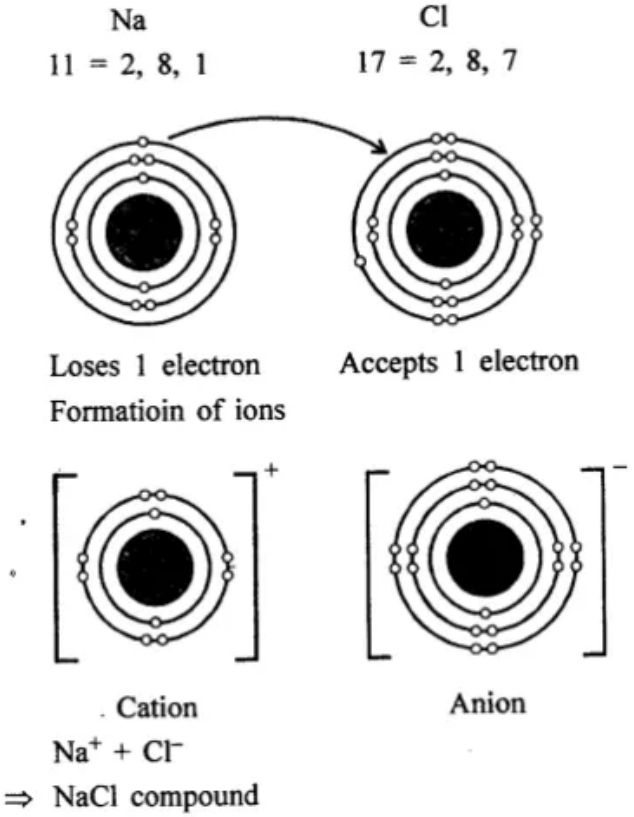
OR
8 electrons in outer most orbit like other nearst noble gas – [Octet].

(b)

1. Valency is the number of electrons donated or lost from the valence shell. Since sodium donates 1 valence electron its valency is +1.
   Magnesium loses 2 electrons and aluminium loses 3 electrons from their valence shell their valency is
   +2 – magnesium
   +3 – Aluminium
2. Valency of an element is the number of electrons accepted to achieve stable configuration of nearest noble gas.
   Chlorine accepts 1 electron and has valency -1 where as oxygen accepts 2 electrons the valency of oxygen is -2 and nitrogen accepts 3 electrons, valency of nitrogen is -3.

Question 14.
With reference to formation of compounds from atoms by electron transfer – electro valency, state the basic steps in the conversion of sodium & chlorine atoms to sodium & chloride ions leading to the formation of the compound – sodium chloride.
[electronic configuration of : Na = 2, 8, 1 & Cl = 2, 8, 7]

Answer:
Electronic configuration



OBJECTIVE TYPE QUESTIONS

Q.1. Match the statements in List I with the correct answer from List II.

List I	List II
1. Mass number of an atom is the number of protons and	A: Electron
2. The sub-atomic particle with a negligible mass.	B: Argon
3. An atom having stable electronic configuration.	C: Nitrogen
4. A molecule formed by sharing of electrons [covalency].	D: Sodium
5. A metallic atom having unstable electronic configuration.	E: Neutrons

Answer:

List I	List II
1. Mass number of an atom is the number of protons and	E: Neutrons
2. The sub-atomic particle with a negligible mass.	A: Electron
3. An atom having stable electronic configuration.	B: Argon
4. A molecule formed by sharing of electrons [covalency].	C: Nitrogen
5. A metallic atom having unstable electronic configuration.	D: Sodium

Q.2. Select the correct answer from the choice in bracket to complete each sentence :

Question 1.
An element 'X has six electrons in its outer or valence shell. Its valency is __ [+2/-2/-1].
Answer:
An element 'X has six electrons in its outer or valence shell. Its valency is **-2.**

Question 2.
An element 'Y' has electronic configuration 2, 8, 6. The element 'Y' is a __ [metal/non-metal/noble gas].

Answer:
An element 'Y' has electronic configuration 2, 8, 6. The element 'Y' is a **non-metal.**

Question 3.
A __ [proton/neutron] is a sub-atomic particle with no charge and unit mass.
Answer:
A **neutron** is a sub-atomic particle with no charge and unit mass.

Question 4.
An element Z with zero valency is a __ [metal/noble gas/non-metal].
Answer:
An element Z with zero valency is a **noble gas.**

Question 5.
Magnesium atom with electronic configuration 2, 8, 2 achieves stable electronic configuration by losing two electrons, thereby achieving stable electronic configuration of the nearest noble gas __ [neon/argon].
Answer:
Magnesium atom with electronic configuration 2, 8, 2 achieves stable electronic configuration by losing two electrons, thereby achieving stable electronic configuration of the nearest noble gas **neon.**

Q.3. The diagram represents an isotope of hydrogen [H]. Answer the following :

At. no. = 1
Mass no. = 1

Question 1.
Are isotopes atoms of the same element or different elements.
Answer:
Isotopes atoms are of the same element.

Question 2.
Do isotopes have the same atomic number or the same mass number.
Answer:
Same atomic number.

Question 3.
If an isotope of 'H' has mass no. = 2, how many electrons does it have.
Answer:
One electron.

Question 4.
If an isotope of 'H' has mass no. = 3, how many neutrons does it have.
Answer:
Two neutrons. [∵ A = P + n]

Question 5.
Which sub-atomic particles in the 3 isotopes of 'H' are the same.
Answer:
Protons and electrons in each isotope are same.

Q.4. State the electronic configuration for each of the following :

1. Hydrogen	**[p = 1]**	**2. Boron**	**[p = 5]**
3. Nitrogen	**[p = 7]**	**4. Neon**	**[p = 10]**
5. Magnesium	**[p = 12]**	**6. Aluminium**	**[p = 13]**
7. Sulphur	**[p = 16]**	**8. Argon**	**[p = 18]**
9. Potassium	**[p = 19]**	**10. Calcium**	**[p = 20]**

Answer:
Electronic configuration of :

1. Hydrogen — $_1H$ is K (1)
2. Boron — B, 5 = K, L : 2, 3
3. Nitrogen — N, 7 = K, L : 2, 5
4. Neon — Ne, 10 = K, L : 2, 8
5. Magnesium — Mg, 12 = K, L, M : 2, 8, 2
6. Aluminium — Al, 13 = K, L, M : 2, 8, 3
7. Sulphur — S, 16 = K, L, M : 2, 8, 6
8. Argon — Ar, 18 = K, L, M : 2, 8, 8
9. Potassium — K, 19 = K, L, M, N : 2, 8, 8, 1

10. Calcium $\underset{20}{Ca}$ $\underset{2,\ 8,\ 8,\ 2}{K, L, M, N}$

Q.5. Draw the structure of the following atoms showing the nucleus containing – protons, neutrons and the orbits with the respective electrons :

1. Lithium [At. no. = 3, Mass no. = 7]
2. Carbon [At. no. = 6, Mass no. = 12]
3. Silicon [At. no. = 14, Mass no. = 28]
4. Sodium [At. no. = 11, Mass no. = 23]
5. Isotopes of hydrogen [1_1H, 2_1H , 3_1H]

Answer:
Structure of atoms :
Z is Atomic Number A is mass number

1. Lithium $^{7}_{3}Li$

$Z = 3 = p = e$

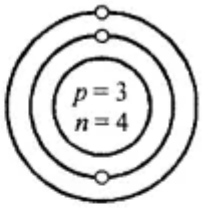
K L

$e = 3 = 2, 1$

$A = p + n$

$7 = 3 + 3$

$\therefore\ n = 7 - 3 = 4$



2. Carbon $^{12}_{6}C$

$Z = 6 = p = e$

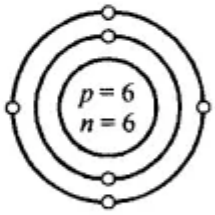
K L

$e = 6 = 2, 4$

$A = p + n$

$12 = 6 + n$

$\therefore\ n = 12 - 6 = 6$

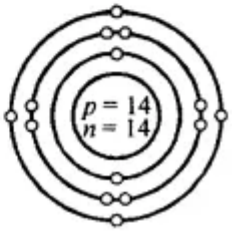


3. Silicon $^{28}_{14}Si$

$Z = 14 = p = e$

K L M

$e = 14 = 2, 8, 4$



$A = p + n$

$28 = 14 + n$

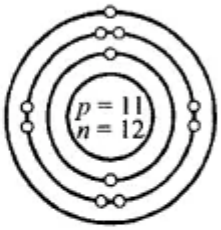
$\therefore\ n = 28 - 14 = 14$

4. Sodium $^{23}_{11}Na$

$Z = 11 = p = e$

K L M

$e = 11 = 2, 8, 1$



$A = p + n$

$23 = 11 + n$

$\therefore\ n = 23 - 11 = 12$

5. Hydrogen isotope $^{1}_{1}H$

$z = 1 = p = e$

$\therefore\ e = 1$

$A = p + n$

$1 = 1 + n$

$\therefore\ n = 1 - 1 = 0$

Proton ⊕

$^{2}_{1}H$

$p = 1$ ⊕
$n = 1$ ●
$e = 1$ ⊘

$^{3}_{1}H$

$p = 1$ ⊕
$n = 1$ ●
$e = 1$ ⊘