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Chapter – 4 Structure of the Atom

Multiple Choice Questions

Q1. 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**

Answer: Option b) 2, 8, 2

Atomic number of Magnesium atom $= 12$

Number of electrons in Magnesium atom $= 12$

So, electronic configuration is $2, 8, 2$

Q2. Rutherford's alpha ($\propto$) particles scattering experiment resulted into discovery of

a) **Electron**
b) **Proton**
c) **Nucleus in the atom**
d) **Atomic mass**

Answer: Option c) Nucleus in the atom

Rutherford's alpha ($\propto$) particles scattering experiment discovered nucleus of an atom.

Q3. 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) $^{15}_{16}X$

Answer: Option a) X_{15}^{31}

Number of electrons in $X = 15$

Number of neutrons in $X = 16$

Atomic number is equal to Number of Protons is further equal to Number of electrons in Neutral atom is equal to 15

Mass number is equal to Number of protons + Number of neutrons

$$= 15 + 16 = 31$$

So, the atom is ${}^{31}_{15}X$.

Q4. 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**

Answer: Option iv)

Dalton's atomic theory explain the law of chemical combination.

Q5. Which of the following statements about Rutherford's model of atom are correct?

- **i) Considered the nucleus as positively charged.**
- **ii) Established that the $\propto -particles$ 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)

Answer: Option a)

Rutherford's model of an atom has a central positively charged nucleus and the electrons revolve around it.

This model of an atom looks same as the solar system so, it is also called planetary model.

Q6. 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 number = 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)

Answer: Option d)

ii) Atomic number = number of protons+ number of electrons

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

Q7. 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 stabilise the atom.

a) i), ii) and iii)
b) i) and iii)
c) i) and iv)
d) i), iii) and iv)

Answer: Option a)

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.

Thomson's model of an atom states that an atom is a sphere which is positively charged with negatively charged electrons in it.

The magnitude of negative electron and positive charge nucleus are equal, so, the atom is electrically neutral.

Q8. Rutherford's $\propto$ - 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) Neutrons 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)

Answer: Option b)

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

iv) Most of the space in atom is empty

Rutherford's alpha particle scattering experiment states that an atom consists of a positively charged, dense and very small nucleus with protons and neutrons. Protons have positive charge and neutrons have no charge.

As alpha particles pass through the gold foil without deflection, so there is empty space.

Q9. 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

Answer: Option b)

Charge $= +3$

Mass number $= 27$

Number of neutrons $= 14$

Atomic number = mass number – number of neutrons $= 27 - 14 = 13$

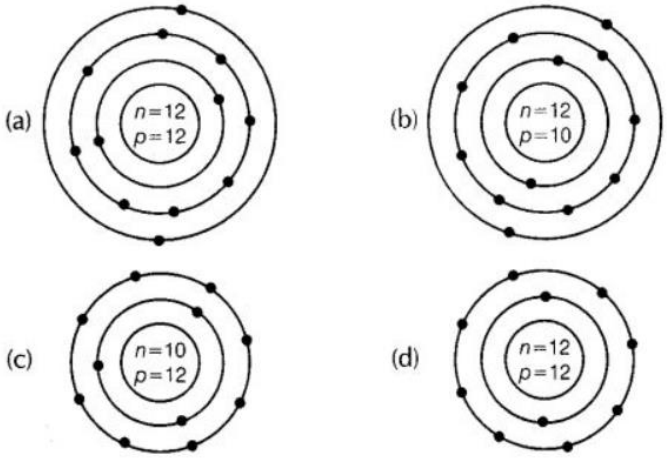
Aluminium has the atomic number $= 13$

Number of electrons in Al atom $= 13$

Number of electrons in the Al^{3+} ion $= 13 - 3 = 10$

It is formed by neutral atom by the loss of 3 electrons.

Q10. Identify the Mg^{2+} ion from the figure where, n and p represent the number of neutrons and protons respectively.



Answer: Option d)

Electronic configuration of Mg atom = 2, 8, 2 that of Mg^{2+} ion = 2, 8

Number of neutrons in Mg atom $= 2 + 8 + 2 = 12$

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

Mass number of Mg atom = 24

Number of neutrons is equal to mass number – number of protons

Q11. 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 have 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.**

Answer: Option c) The two oxygen atoms are isotopes.

Two O-atoms in $CH_3COOC_2H_5$ have different number of neutrons, if two O-atoms are isotopes, as isotopes of an element have same number of protons but different number of neutrons.

Q12. Elements with valency 1 are

a) **Always metals**
b) **Always metalloids**
c) **Either metals or non-metals**
d) **Always non-metals**

Answer: Option c) Either metals or non-metals

Metals which have one valence electron and non-metals which have seven valence electrons, valency is equal to one, as metals loose $1e^-$ and non-metals gain $1e^-$ to complete their octet.

Q13. The first model of an atom was given by

a) **N Bohr**
b) **E Goldstein**
c) **Rutherford**
d) **J.J Thomson**

Answer: Option d)

The first model of an atom was given by J.J Thomson.

Q14. An atom with 3 protons and 4 neutrons will have a valency of

a) **3**
b) **7**
c) **1**
d) **4**

Answer: Option c)

Number of protons in an atom = 3

Number of neutrons = 4

Electronic configuration of Lithium = 2, 1

It has one valence electron, so valency is 1.

Q15. The electron distribution in an aluminium atom is

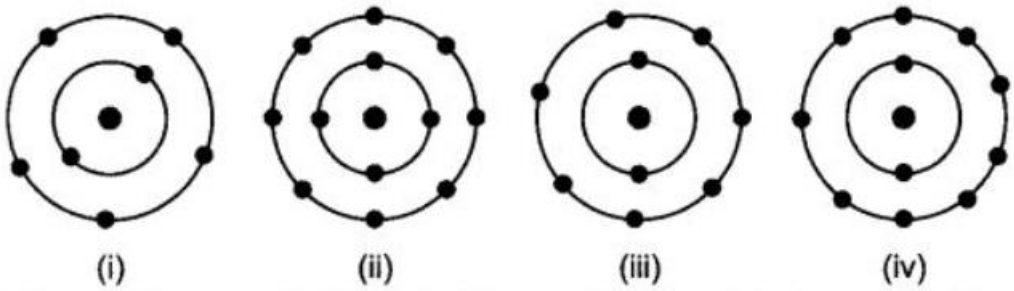
a) **2, 8, 3**
b) **2, 8, 2**
c) **8, 2, 3**
d) **2, 3, 8**

Answer: Option **a) 2, 8, 3**

Aluminium atom has protons = electrons = 13

Electronic configuration of $Al = 2, 8, 3$

Q16. Which of the following in figure do not represent Bohr's model of an atom correctly?



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

Answer: Option c)

Figure (ii) and (iv) are incorrect illustration of the Bohr's model of an atom, because maximum number of electrons in K shell is 2, not 4, so figure (ii) is wrong. Maximum number of electrons of L shell is 8 electrons, not 9, so figure (iv) is also wrong.

Q17. Which of the following statement 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

Answer: Option a)

An atom is electrically neutral, because an atom has equal number of protons and electrons.

Q18. Atomic models have been improved over the years. Arrange the following atomic 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)

Answer: Option c)

The chronology in advancement of atomic model started from Thomson's model, then Rutherford alpha particle scattering experiment and then finally Bohr's atomic model.

Short Answer Type Questions

Q19. Is it possible for the atom of an element to have one electron, one proton and no neutron? If so, name the element.

Answer:

Yes, an atom has one proton, one electron and no neutron. The element is protium $^{1}_{1}H$, an isotope of hydrogen.

Q20. Write any two observations which support the fact that atoms are divisible.

Answer:

The following observations show that atoms formed from different particles like electrons, protons and neutrons, i.e., atoms are divisible –

i) An ionic compound involves the transfer of electrons and form ions

ii) The isotopes of the same elements are formed because of difference in the number of neutrons.

Q21. Will ^{35}Cl and ^{37}Cl have different valences? Justify your answer.

Answer:

No, ^{35}Cl and ^{37}Cl have the same valences, ^{35}Cl and ^{37}Cl are the isotopes. They have same number of protons, electrons and atomic number i.e., 17.

So, their electronic configuration and valences is also same.

Electronic configuration $= 2, 8, 7$

Valency $8 - 7 = 1$

Therefore, both $^{35}_{17}Cl$ and $^{37}_{17}Cl$ have same valency = 1

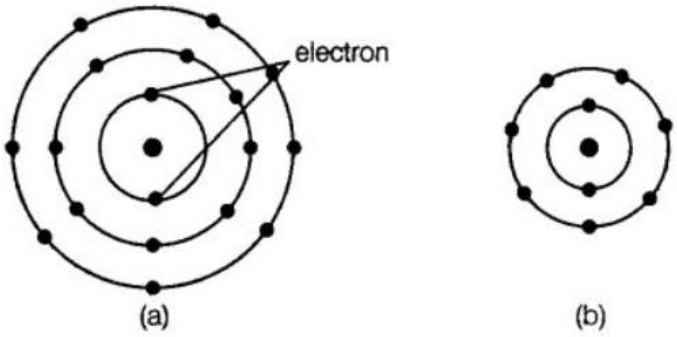
Q22. Why did Rutherford select a gold foil in his $\propto -ray$ scattering experiment?

Answer:

Gold is a heavy metal and also malleable. A thin foil ($\approx 1000\ atoms\ thick$) is made from gold easily.

A light weight metal is not used because when the fast moving ∝- particles strike it, the atom of light metal is pushed and no scattering occur.

Q23. Find out the valency of the atoms represented by the Figure (a) and (b).



Answer:

a) For figure (a), electronic configuration

K	L	M
2	8	8

Outer shell is completely filled to form an octet.
So, valency $= 0$

b) For figure (b), electronic configuration

K	L
2	7

It requires one electron to complete its octet, so gain one electron easily.
So, valency $= 1$

Q24. 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?

Answer:

An element X is a metal, as 1 electron is present in the outermost shell, i.e., 1 valence electron.

When valence electron is removed from the outer shell, a positive ion is formed with a charge of $+1$.

Q25. Write down the electron distribution of chlorine atom. How many electrons are there in the L – shell? Atomic number of chlorine is $= 17$.

Answer:

Atomic number of chlorine atom $= 17$.

So, the electronic configuration is

K	L	M
2	8	7

L shell of chlorine has 8 electrons.

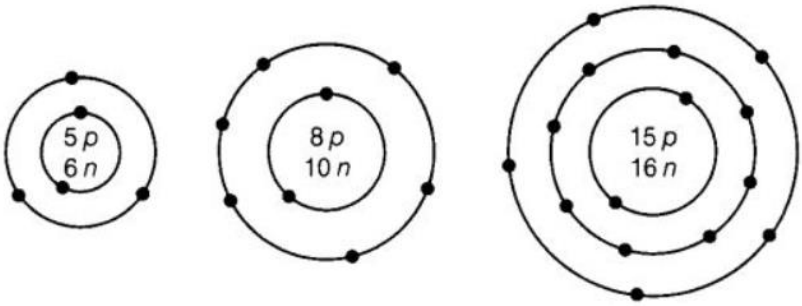
Q26. In the atom of an element X, 6 electrons are present in the outermost shell. If it acquires noble gas configuration by accepting requisite number of electrons, then what would be the charge on the ion so formed?

Answer:

The element X has 6 electrons in the outermost shell. So, for noble gas configuration, element X requires 2 electrons.

So, the charge on the anion (X^{2-}) is -2.

Q27. 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)

Answer:

Element	Atomic number (= no. of p)	Mass number = {no. of (p + n)}	Number of electrons (= no. of p)	Electronic configuration	Valency
X	5	$5+6=11$	5	$2,3$	3
Y	8	$8+10=18$	8	$2,6$	2
Z	15	$15+16=31$	15	$2,8,5$	$3,5$

Q28. 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.

Answer:

Th statement given is incorrect.

$$p > n > e$$

Number of protons is never greater than that of neutrons.

Number of neutrons is equal to or greater than the number of protons as mass number is equal to or double the atomic number or greater than double the atomic number.

In neutral atom, the number of electrons = number of protons, so the number of neutrons is greater than number of electrons.

Q29. Calculate the number of neutrons present in the nucleus of an element X which is represented as $^{31}_{15}X$.

Answer:

Element X is represented as $^{31}_{15}X$, so

Atomic number, $Z = 15$

Mass number, $A = 31$

Number of neutrons $= A - Z = 31 - 15 = 16$

Q30.Match the names of the Scientist given in Column A with their contributions towards the understanding of the atomic structure as given in Column B.

Column A	Column B
a) Ernest Rutherford	Indivisibility of atoms
b) J.J Thomson	Stationary orbits
c) Dalton	Concept of nucleus
d) Neil's Bohr	Discovery of electrons
e) James Chadwick	Atomic number
f) E Goldstein	Neutron
g) Mosley	Canal rays

Answer:

Column A	Column B
h) Ernest Rutherford	Concept of nucleus
i) J.J Thomson	Discovery of electrons
j) Dalton	Indivisibility of atoms
k) Neil's Bohr	Stationary orbits
l) James Chadwick	Neutron
m) E Goldstein	Atomic number
n) Mosley	Canal rays

Q31. 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?

Answer:

Mass number of Ca (Calcium) = $^{40}_{20}C$

Mass of number of Ar (Argon) = $^{40}_{18}Ar$

So, the pair of elements with same mass number but different atomic number is called isobars.

Q32. Complete the 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

Answer:

Formula to be used: -

$Number\ of\ protons\quad (n_p)\quad = atomic\ number\ of\ atoms\ and\ number\ of\ neutrons\ (n_n)\quad = mass\ number - atomic\ number.$

Element	$\boldsymbol{n_p}$	$\boldsymbol{n_n}$
$^{35}_{17}Cl$	17	$35 - 17 = 18$
$^{12}_{6}C$	6	$12 - 6 = 6$
$^{81}_{35}Br$	35	$81 - 35 = 46$

Q33. Helium atom has 2 electrons in its valence shell but its valency is not 2. Explain.

Answer:

Helium atom has one K shell which have 2 electrons.

It means the shell is complete, and called as duplet that is, it can neither gain any electron nor lose.

So, its valency is 0 (Zero).

It is also called as noble gas, inert gas or rare gas.

Q34. Fill in the blanks in the following statements.

a) **Rutherford's $\propto -particles$ scattering experiment lead to the discovery of the _____**
b) **Isotopes have same _____ but different _____**
c) **Neon and chlorine have atomic numbers 10 and 17 respectively. Their valences will be _____ and _____ respectively.**
d) **The electronic configuration of silicon is _____ and that of sulphur is _____**

Answer:

a) **nucleus**.
b) **atomic number** and **mass number**.
c) **zero** and **one** .
d) **2, 8, 4** and **2, 8, 6**.

Q35. An element X has a mass number 4 and atomic number 2. Write the valency of this element.

Answer:

Mass number $= 4$

Atomic number $= 2$

Number of electrons will be $= 2$

So, the element has K shell with 2 electrons, which means it is duplet.

So, the valency of the element is equal to Zero.

The element X is the noble gas ${}^{4}_{2}H$.

Long Answer Type Questions

Q36. Why do helium, neon and argon have a zero valency?

Answer:

Helium (He), Neon (Ne) and Argon (Ar) all three have filled outer shell.

The electronic configuration is shown as: -

$He \rightarrow \quad K = 2$ (duplet)

$Ne \rightarrow \quad K = 2, L = 8$ (octet)

$Ar \rightarrow \quad K = 2, L = 8, M = 8$ (octet)

Helium, Neon and Argon have stable electronic configuration, i.e., they neither lose electrons nor gain electrons. So, their valency is Zero.

Q37. The ratio of the radii of hydrogen atom and its nucleus is $\approx 10^5$. Assuming the atom and the nucleus to be spherical.

a) **What will be the ratio of their sizes?**
b) **If atom is represented by planet earth $'Re' = 6.4 \times 10^6\ m$, estimate the size of the nucleus.**

Answer:

a) Atomic size is expressed in terms of atomic radius,

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

the volume of sphere,

$$= \frac{4}{3}\pi r^3$$

$$V_H = \frac{4}{3}\pi r_H^3$$

$$V_n = \frac{4}{3}\pi r_n^3$$

So, the ratio of volumes,

$$\frac{V_H}{V_n} = \frac{\frac{4}{3}\pi r_H^3}{\frac{4}{3}\pi r_n^3} = \frac{r_H^3}{r_n^3} = (10^5)^3 = 10^{15}$$

b) the size of the nucleus –

$$\frac{V_n}{V_H} = 10^{-15}$$

$or,$

$$V_n = 10^{-15} \times V_H$$

If atom is represented as planet earth with $Re = 6.4 \times 10^6\ m$

volume of atom,

$$V_H = \frac{4}{3}\pi Re_e^3$$

$$= \frac{4}{3} \times 3.14 \times (6.4 \times 10^6\ m)^3$$

$$= 1097.5 \times 10^{18} m^3$$

$$= 10975 \times 10^{21} m^3$$

$$Volume\ of\ nucleus = 10^{-15} \times (1.0975 \times 10^{21}) m^3$$

$$= 1.0975 \times 10^6\ m^3$$

So, if the atom is represented as planet earth then the size of the nucleus $= 1.0975 \times 10^6\ m^3$

Q38. Enlist the conclusions drawn by Rutherford from his ∝-ray scattering experiment.

Answer:

The conclusions from the Rutherford's ∝-ray scattering experiment are: -

i) There are empty spaces inside the atom as ∝-ray particles are passed through the gold foil without getting deflected.
ii) There are few particles or rays deflected from their path thus, positive charge of the atom occupies less space.
iii) A small fraction of ∝-ray particles are deflected by 180^o, which show that positive charge and mass of gold atom are in small volume with an atom.

Q39. In what way is the Rutherford's atomic model different from that of Thomson's atomic model?

Answer:

In Rutherford's model of an atom, the positive charge and mass of an atom are in small nucleus in the centre of an atom and negatively charged electrons are revolving around the nucleus.

Whereas in Thomson's model, an atom is a positively charged sphere with electrons in it, which neutralises the positive charge and an atom is electrically neutral.

Q40. What were the drawbacks of Rutherford's model of an atom?

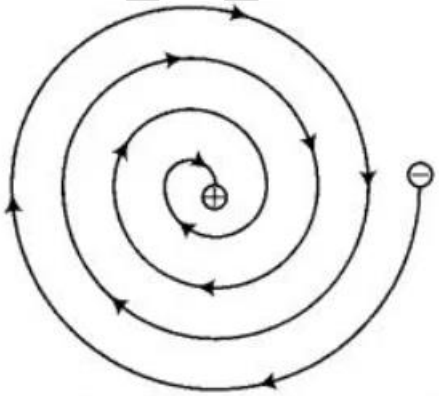
Answer:

Drawbacks of Rutherford's model of an atom: -

Rutherford's model do not explain the stability of an atom, as an atom consists of positively charge nucleus in the centre and the electrons revolving around it.

These revolving electrons lose energy as they are charged particles and due to acceleration, radiate energy.

So, the orbit of the revolving electron become smaller as the spiral path shown below. And ultimately electron fall into the nucleus and atom collapses.



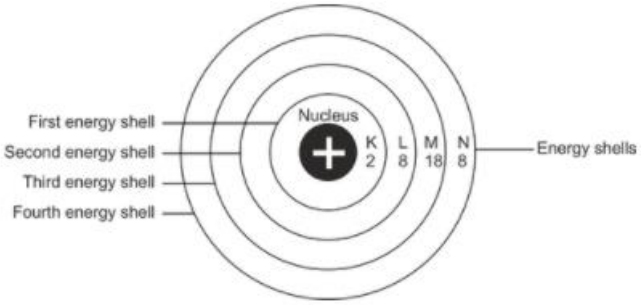
Continuous loss of energy by a revolving electron

Q41. What are the postulates of Bohr's model of an atom?

Answer:

The postulates of Bohr's model of an atom are: -

i) In an atom, the electrons revolve around the nucleus in definite circular paths called as orbits or shells.
These are K, L, M, N. . . . or as n = 1, 2, 3, 4. . . . .



ii) The maximum number of electrons in a shell is calculated by formula $2n^2$, where 'n' is the orbit 1, 2, 3. . . The number of electrons in various shells are as follows:

iii) The maximum number of electrons in the outer orbit is eight.

iv) Outer shells are filled with electrons after inner shells are filled.

v) When electrons revolving in the discrete orbit do not radiate energy.

Q42. Show diagrammatically the electron distribution in a sodium atom and a sodium ion and also give their atomic number.

Answer:

The Atomic number of sodium $(Z) = 11$

The Mass number of sodium $(A) = 23$

Number of protons $= 11$

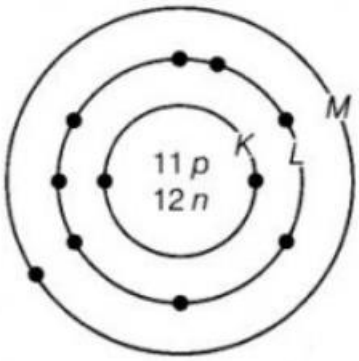
Number of neutrons $= 23 - 11 = 12$

Number of electrons $= 11$

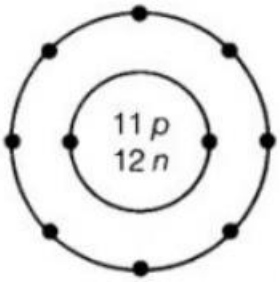
electronic configuration of Na atom $= 2, 8, 1$ (K, L, M shells respectively)

The Na^+ ion is formed from sodium atom by loss of an electron.

So, the electronic configuration is $2, 8$ in K, L respectively.



Sodium atom



Sodium ion

Q43. In the gold foil experiment of Geiger and Marsden, that paved the way for Rutherford's model of an atom, $\sim 1.00\%$ of the $\propto$-particles were found to deflect at angles > 50^o. If one mole of $\propto$-particles were bombarded on the gold foil, compute the number of $\propto$-particles that would deflect at angles less than 50^o.

Answer:

Total number of $\propto$-particles used for bombardment $= 1\ mole$

$$1\ mole = 6.022 \times 10^{23}\ particles$$

Number of $\propto$-particles deflected at angles greater than

$$50^o\ (> 50^o) = 1\%$$

Number of $\propto$-particles deflected at the angles less than

$$50^o = 100 - 1 = 99\%$$

So, the actual number of $\propto$-particles deflected at the angles less than

$$50^o = \frac{99}{100} \times 6.022 \times 10^{23}$$

$$= 5.96 \times 10^{23}$$