**Atoms**

Atoms are the building blocks of matter. It is the smallest unit of matter that is composed of three sub-atomic particles: the proton, the neutron and the electron.

* Atoms are the basic building blocks of matter.
* Different kinds of matter exist because there are different kinds of atoms present in them.

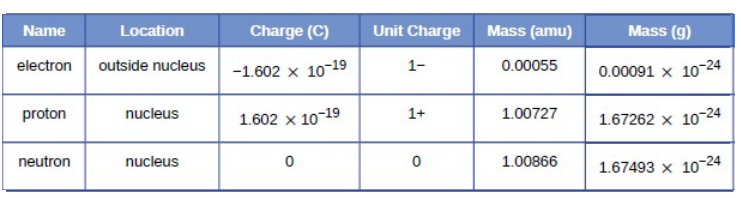
## ****Charged Particles in Matter****

* Whenever we rub two objects together, they become electrically charged. This is because atoms contain charged particles in them. Therefore, atoms can be divided further into particles i.e proton, electron and neutron.

**Protons were discovered by Ernest Rutherford, in his famous gold foil experiment**.

**Electrons were discovered by J.J. Thomson, in his cathode ray tube experiment**.

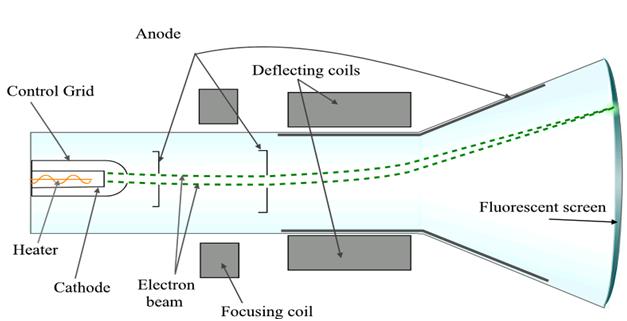
**Neutrons were discovered by James Chadwick**.



* Atoms consist of protons and electrons in a balanced proportion.
* Protons exist in the interiors of the atom and electrons exist in the exteriors of the atom. Therefore, electrons can be removed from an atom

**Cathode Ray Experiment**

* J. J. Thomson discovered the existence of electrons.
* He did this using a **cathode ray** tube, which is a vacuum-sealed tube with a **cathode** and anode on one end that created a beam of electrons travelling towards the other end of the tube.
* The air inside the chamber is subjected to high voltage, and electricity flows through the air from the negative electrode to the positive electrode.
* The characteristics of cathode rays (electrons) do not depend upon the material of electrodes and the nature of the gas present in the cathode ray tube.
* The experiment showed that the atom was not a simple, indivisible particle and contained at least one subatomic particle – the electron.



## Cathode Ray Tube

J. J. Thomson designed a glass tube that was partly evacuated, i.e. all the air had been drained out of the building. He then applied a high electric voltage at either end of the tube between two electrodes. He observed a particle stream (ray) coming out of the negatively charged electrode (cathode) to the positively charged electrode (anode). This ray is called a cathode ray and is called a cathode ray tube for the entire construction.

The experiment Cathode Ray Tube (CRT) conducted by J. J. Thomson, is one of the most well-known physical experiments that led to electron discovery. In addition, the experiment could describe characteristic properties, in essence, its affinity to positive charge, and its charge to mass ratio. This paper describes how J is simulated. J. Thomson experimented with Cathode Ray Tube.

The major contribution of this work is the new approach to modelling this experiment, using the equations of physical laws to describe the electrons’ motion with a great deal of accuracy and precision. The user can manipulate and record the movement of the electrons by assigning various values to the experimental parameters.

The apparatus of the experiment incorporated a tube made of glass containing two pieces of metals at the opposite ends which acted as an electrode. The two metal pieces were connected with an external voltage. The pressure of the gas inside the tube was lowered by evacuating the air.

Procedure of the Experiment

1. Apparatus is set up by providing a high voltage source and evacuating the air to maintain the low pressure inside the tube.
2. High voltage is passed to the two metal pieces to ionize the air and make it a conductor of electricity.
3. The electricity starts flowing as the circuit was complete.
4. To identify the constituents of the ray produced by applying a high voltage to the tube, the dipole was set up as an add-on in the experiment.
5. The positive pole and negative pole were kept on either side of the discharge ray.
6. When the dipoles were applied, the ray was repelled by the negative pole and it was deflected towards the positive pole.
7. This was further confirmed by placing the phosphorescent substance at the end of the discharge ray. It glows when hit by a discharge ray. By carefully observing the places where fluorescence was observed, it was noted that the deflections were on the positive side. So the constituents of the discharge tube were negatively charged.

## Conclusion

After completing the experiment J.J. Thomson concluded that rays were and are basically negatively charged particles present or moving around in a set of a positive charge. This theory further helped physicists in understanding the structure of an atom. And the significant observation that he made was that the characteristics of cathode rays or electrons did not depend on the material of electrodes or the nature of the gas present in the cathode ray tube. All in all, from all this we learn that the electrons are in fact the basic constituent of all the atoms.

Most of the mass of the atom and all of its positive charge are contained in a small nucleus, called a nucleus. The particle which is positively charged is called a proton. The greater part of an atom’s volume is empty space.

The number of electrons that are dispersed outside the nucleus is the same as the number of positively charged protons in the nucleus. This explains the electrical neutrality of an atom as a whole.

**Uses of Cathode Ray Tube**

1. Used as a most popular television (TV) display.
2. X-rays are produced when fast-moving cathode rays are stopped suddenly.
3. The screen of a cathode ray oscilloscope, and the monitor of a computer, are coated with fluorescent substances. When the cathode rays fall off the screen pictures are visible on the screen.

## ****Failure of Dalton’s Atomic Theory****

The postulates of the atomic theory by John Dalton

* The matter is made up of tiny particles called **Atoms** that cannot be divided.
* Atoms are never formed or destroyed during a chemical reaction.
* Atoms of an element exhibit same nature. They have the same size, mass, and character.
* Atoms of different elements exhibit variant nature. They do not have same characteristics.
* Atoms form compounds by combining in a ratio of whole numbers.
* A compound contains a constant number and kinds of atoms

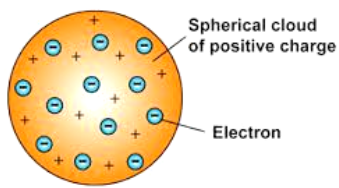
Dalton suggested that atoms can neither be created nor destroyed and are indivisible. But the discovery of electrons and protons in atoms lead to failure of this aspect of Dalton’s theory.

**Electrons**

* Electrons are the negatively charged sub-atomic particles of an atom.
* The mass of an electron is considered to be negligible, and its charge is -1.
* The symbol for an electron is e–
* Electrons are extremely small.
* They are found outside the nucleus.

**Thomson’s Model of an Atom**

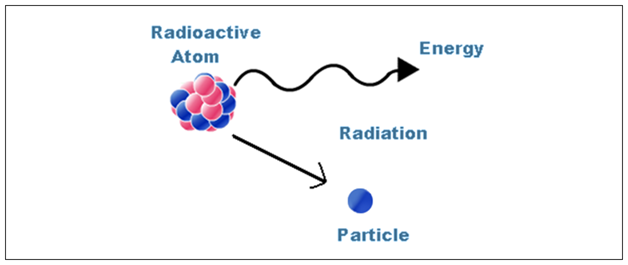
* According to J.J. Thomson, the structure of an atom can be compared to Christmas pudding where electrons are present inside a positive sphere.



* An atom is composed of a positively charged sphere in which electrons are embedded.
* Atom is neutral as the positive and negative charged are equal in proportion.
* According to Thomson,(i) An atom consists of a positively charged sphere and the electrons are embedded in it. (ii) The negative and positive charges are equal in magnitude. So, the atom as a whole is electrically neutral
* The first model of an atom to be put forward and taken into consideration.
* He proposed a model of the atom be similar to that of a Christmas pudding/watermelon.
* The red edible part of the watermelon is compared with the positive charge in the atom.
* The black seeds in the watermelon are compared with the electrons which are embedded on it.

**Radioactivity**

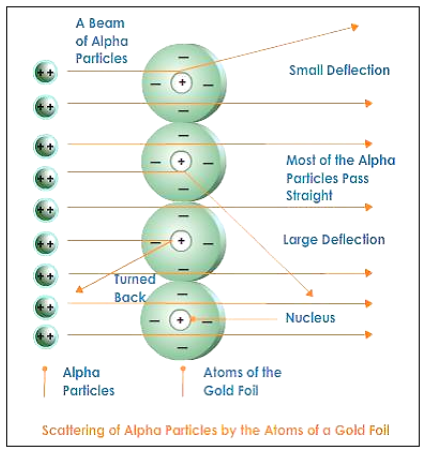
* Radioactivity is the term for the process by which an unstable nucleus of an atom loses energy by giving out particles.
* It does so by giving out particles such as alpha and beta particles.
* This process is spontaneous.
* An atom is unstable if the nucleus has an imbalance, meaning a difference in the protons and neutrons.



## Rutherford Model

### ****Rutherford’s Experiment and Observations****

* He experimented with thin gold foil by passing alpha rays through it.
* He expected that the gold atoms will deflect the Alpha particles.



|  |  |
| --- | --- |
| **Observations** | **Inferences** |
| Alpha particles which had high speed moved straight through the gold foil | Atom contains a lot of empty space |
| Some particles got diverted a by slide angles | Positive charges in the atom are not occupying much of its space |
| Only one out of 12000 particles bounced back | The positive charges are concentrated over a particular area of the atom |

Thus, Rutherford gave the nuclear model of an atom based on his experiment which suggests that fast-moving alpha (α)-particles were made to fall on a thin gold foil. His observations were:

* Atoms contain a lot of unoccupied space
* There is a heavily positively charged substance present in the center of the atom which is called the nucleus
* The nucleus contains an equal amount of positive and negative charge.
* A major fraction of the α-particles bombarded towards the gold sheet passed through it without any deflection, and hence **most of the space in an atom is empty**.
* Some of the α-particles were deflected by the gold sheet by very small angles, and hence the **positive charge** in an atom **is not uniformly distributed**.
* **The positive charge**in an atom**is concentrated in a very small volume**.
* Very few of the α-particles were deflected back; that is, only a few α-particles had nearly 180o angle of deflection. So the **volume occupied by the positively charged particles in an atom is very small as compared to the total volume of an atom**.

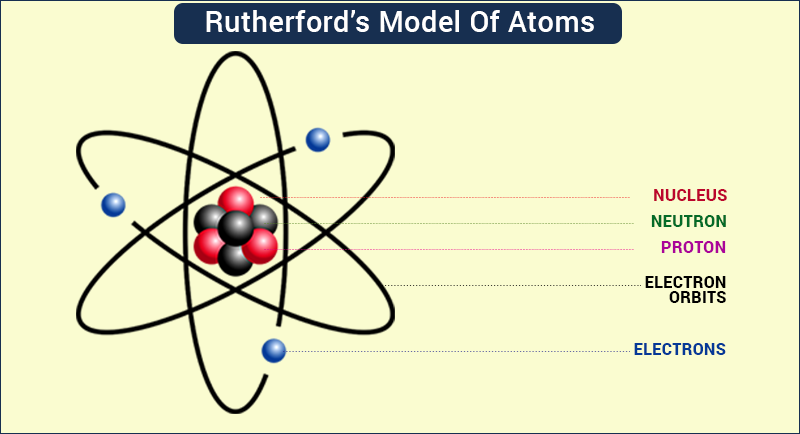
**Rutherford’s Model of an Atom**

Rutherford concluded the model of the atom from the α-particle scattering experiment as follows:

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

(ii) The electrons revolve around the nucleus in well-defined orbits.

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

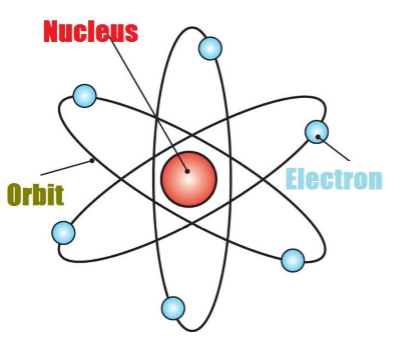


**Drawbacks of Rutherford’s Model**

* He explained that the electrons in an atom revolve around the nucleus in well-defined orbits. Particles in a circular orbit would experience acceleration.
* Thus, the revolving electron would lose energy and finally fall into the nucleus.
* But this cannot take place as the atom would be unstable, and the matter would not exist in the form we know.

## ****The Nucleus of an Atom****

* The nucleus id located at the center of the atom.
* All the mass of the atom is because of the nucleus.
* The electrons revolve around the nucleus in circular parts which are called **Orbits**
* If we compare the size of the atom and nucleus, the nucleus is much smaller than the atom.



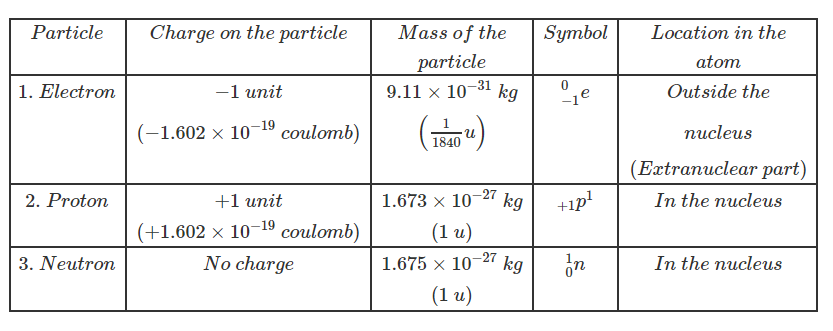
### ****Drawbacks of the Nuclear Model of an Atom****

The Nuclear Model of the Atom failed to explain how an atom remains stable despite having positive and negative charges present in it. Maxwell has suggested a theory according to which if any charged particle moves in a circular motion it radiates energy. So, if electrons start moving in a circular motion around the nucleus they would also radiate some energy which would decrease at the speed of the electrons. As a result, they would fall into the nucleus because of its high positive charge.

**What are nucleons?** –  Protons and Neutrons are collectively called as **Nucleons**.

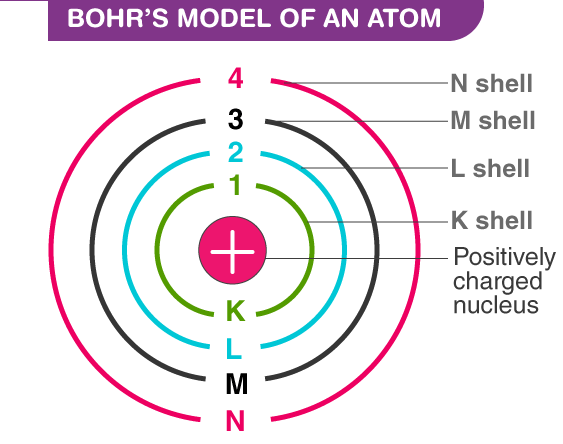
## ****Neil**** ****Bohr's Model of an Atom****

### Properties of Electrons, Protons and Neutrons



Bohr came up with the following postulates to overcome the objections raised against Rutherford’s model.

* Electrons revolve around the nucleus in stable orbits without the emission of radiant energy. Each orbit has a definite energy and is called an energy shell or energy level.
* An orbit or energy level is designated as K, L, M, and N shells. When the electron is in the lowest energy level, it is said to be in the ground state.
* An electron emits or absorbs energy when it jumps from one orbit or energy level to another.
* When it jumps from a higher energy level to a lower energy level, it emits energy, while it absorbs energy when it jumps from a lower energy level to a higher energy level.
* Electrons spin around the nucleus in an individualized separate path or unattached orbit.
* The electrons do not emit any energy while moving Indies special orbits.
* These orbits are also called as **Energy Levels**.
* They are represented using letters or numbers as shown in the figure below –



## ****The Neutrons****

J. Chadwick discovered that there is another sub-atomic particle present in the atom. This particle carries no charge and is known as a **Neutron**. Therefore, we can conclude that atom consists of three types of particles –

|  |  |
| --- | --- |
| **Electrons** | which carry a negative charge |
| **Protons** | which carry a positive charge |
| **Neutrons** | they are neutral |

**Orbits**

Orbits are energy shells surrounding the nucleus in which electrons revolve.

**Electron Distribution in Different Orbits**

The distribution was suggested by Bohr and Bury.

* The maximum number of electrons present in a shell is given by the formula 2n2, where ‘n’ is the orbit number or energy level index, 1,2,3,….
* The maximum number of electrons in different shells are as follows: the first orbit will have 2\*12=2, the second orbit will have 2\*2Msup>2=8, the third orbit will have 2\*32=18, the fourth orbit 2\*42=32 and so on.
* The shells are always filled in a step-wise manner from the lower to higher energy levels. Electrons are not filled in the next shell unless previous shells are filled.

### ****The distribution of electrons in different shells or orbits****

* If Orbit number = n
* Then number of electrons present in an Orbit = 2n2
* So, for n =1
* Maximum electrons present in shell – K = 2 \* (1)2 = 2
* The outermost shell can contain at most 8 electrons.
* The shells in an atom are filled in sequence.
* Thus, until the inner shells of an atom are filled completely the outer shells cannot contain any electrons.

**Valency**

* **Valence Electrons** – Electrons existing in the outermost orbit of an atom are called **Valence Electrons**.
* The combining capacity of the atoms or their tendency to react and form molecules with atoms of the same or different elements is known as the valency of the atom.
* The valency of an atom or the combining capacity of an atom is given by the number of elements present in the outermost shell.
* Atoms of elements, having a completely filled outermost shell, show little chemical activity.
* **For Example**, Helium contains two electrons in its outermost shell which means its valency is two. In other words, it can share two electrons to form a chemical bond with another element.
* Their combining capacity or valency is zero.
* For example, we know that the number of electrons in the outermost shell of hydrogen is 1, and in magnesium, it is 2.
* Therefore, the valency of hydrogen is 1 as it can easily lose 1 electron and become stable.
* On the other hand, that of magnesium is 2 as it can lose 2 electrons easily and also attain stability.

**What happens when the outermost shell contains a number of electrons that are close to its maximum capacity?**

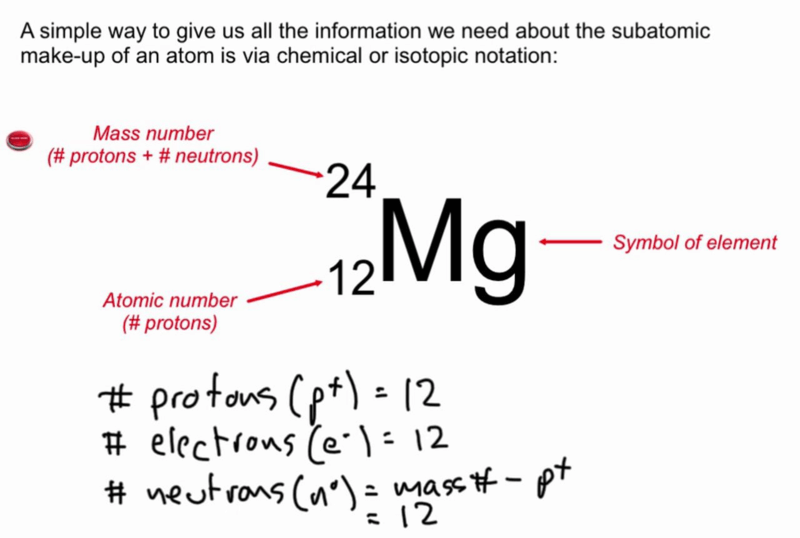
Valency in such cases is generated by subtracting the number of electrons present in the outermost orbit from octet (8). For example, oxygen contains 6 electrons in its outermost shell. Its valency is calculated as: 8 – 6 = 2. This means oxygen needs two electrons to form a bond with another element.

### ****Atomic Number****

The number of protons found in the nucleus of an atom is termed the atomic number. It is denoted by the letter ‘Z’.

### ****Mass Number and Representation of an Atom****

Protons and neutrons are present in the nucleus, so the mass number is the total of these protons and neutrons.

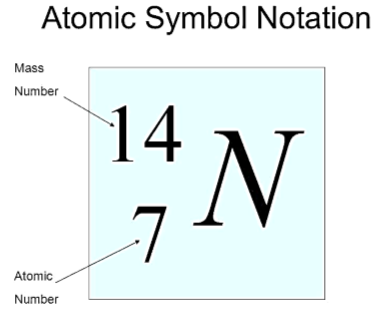


**Atomic Number of an Element**

**Atomic Number** (Z) = Number of protons in an atom

**Mass Number of an Element**

**Mass Number** = Number of protons + Number of neutrons

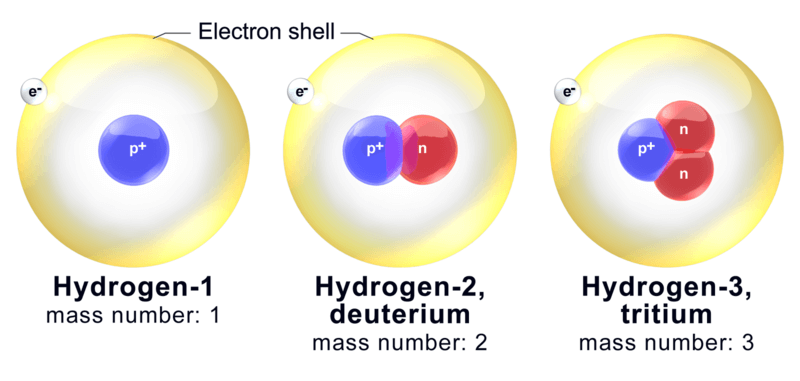


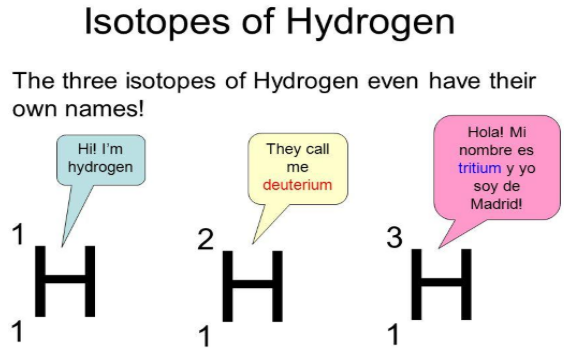
### ****Isotopes and Isobars****

Isotopes are defined as the atoms of the same element, having the same atomic number ( number of protons ) but different mass numbers ( number of protons+neutrons ).

* The atoms of an element can exist in several forms having similar atomic numbers but varying mass numbers.
* Isotopes are pure substances.
* Isotopes have a similar chemical nature.
* Isotopes have distinct physical characteristics.

For example: In the case of Hydrogen we have:





**Where can we use Isotopes?**

1. The fuel of Nuclear Reactor – Isotope of Uranium

2. Treatment of Cancer – Isotope of Cobalt

3. Treatment of Goiter – Isotope of Iodine

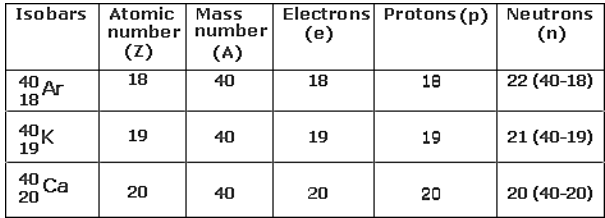
**Example**: Consider two atomic species namely U and V. Are they isotopes?

|  |  |  |
| --- | --- | --- |
|  | **U** | **V** |
| **Protons** | 5 | 5 |
| **Neutrons** | 5 | 6 |
| **Mass Number** | 5 + 5 = 10 | 5 + 6 = 11 |
| **Atomic Number** | 5 | 5 |

From the above example, we can infer that U and V are isotopes because their atomic number is the same.

## ****Isobars****

The atoms of several elements can have a similar mass number but distinct atomic masses. Such elements are called **Isobars**.



**Calculation of Mass Number for Isotopic Elements**

When an element has an isotope, the mass number can be calculated by the different proportions it exists in.

For example, take 98% Carbon-12u and 2% Carbon-13u

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This does not mean that any Carbon atoms exist with a mass number of 12.02u. If you take a certain amount of Carbon, it will contain both isotopes of Carbon, and the average mass is 12.02 u.

**Question** Which subatomic particle is absent in an ordinary hydrogen atom?

**Answer** Neutron.

**Question** J. Chadwick discovered a subatomic particle which has no charge and has mass nearly equal to that of a proton. Name the particle and give its location in the atom.

**Answer** The particle is neutron and it is present in the nucleus of the atom.

**Question** 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, it is true for hydrogen atom which is represented as 11H.

**Question** Electron attributes negative charge, protons attribute positive charge. An atom has both but why there is no charge?

**Answer** The positive and negative charges of protons and electrons are equal in magnitude. So, atom as a whole is electrically neutral.

**Question** Write the electronic configuration of an element whose atomic number is 12.

**Answer**

K, L, M

2, 8, 2

**Question** What do you understand by ground state of an atom?

**Answer** The state of an atom where all the electrons in the atom are in their lowest energy levels is called the ground state.

**Question** What is the maximum number of electrons which can be accommodated in ‘N’ shell?

**Answer** N shell can accommodate maximum 32 electrons.

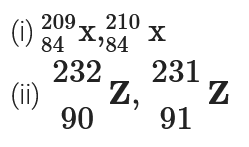
**Question** Write the correct representation of an element ‘X’ which contains 15 electrons and sixteen neutrons.

**Answer** The correct representation of the element X is 

**Question** What will be the valency of an atom if it contains 3 protons and 4 neutrons?

**Answer** The valency of the atom will be one.

**Question** Which of the following pairs are isotopes?



**Answer**   are isotopes.

**Question** Out of elements, which is chemically more reactive and why?  
**Answer** The elements is more reactive because its outermost shell is incomplete.

**Question** 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** The charge would be +1.

**Question** 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** – 2.

**Question** Give two important applications of radioactive isotopes.

**Answer**

* An isotope of carbon-12, C14, is used in carbon dating.
* U235 is used in the nuclear reactors to generate electricity.

**Question** Which isotope of hydrogen is present in heavy water?

**Answer** Among the three isotopes of hydrogen, deuterium (21H)is found in heavy water.

**Question** Chemical formula of a metal sulphate is MSO4. What will be the formula of its chloride?

**Answer** MCl2

**Question** An element ‘A’ has valency +3, while another element ‘B’ has valency -2. Give the formula of their compound formed when ‘A’ reacts with ‘B’.

**Answer** Element ‘A’ valency +3 (left)

Element ‘B’ valency – 2 (right)

Structure of the Atom Class 9 Extra Questions Science Chapter 4 1

Chemical formula = A2B3

**Question** Valency of an element X is 3. Write the chemical formula of its oxide.

**Answer** X2O3

**Question** Will 35Cl and 37Cl have different valencies? Justify your **Answer**.

**Answer** No, 35Cl and 37Cl are isotopes of an element.

**Question** 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** Isobars

**Question** How do you know that nucleus is very small as compared to the size of atom?

**Answer** Rutherford observed that when a-particles were bombarded on a very thin foil they bounced back. But the number of a-particles bouncing back got doubled when he doubled the thickness of gold foil. Then he concluded that the area of nucleus is very small in comparison to the total area of the atom.

**Question** Write two characteristics of the canal rays.

**Answer**

* The canal rays are deflected by the magnetic fields in a direction opposite to that of the cathode rays.
* They consist of positively charged particles.

**Question** Write the electronic configuration of a positively charged sodium ion (Na+). Atomic number of sodium is 11.

**Answer** Number of electrons in Na atom = Atomic number = 11

Number of electrons in Na+ ion = 11 – 1 = 10

Electronic configuration of Na+ ion: 2, 8

**Question** The electronic configuration of phosphorus atom is 2, 8, 5. Give the electronic configuration of P3- ion.

**Answer** Electronic configuration of P = 2, 8, 5

P atom gains 3e– to form P3-

∴ P3- has configuration = 2, 8, (5 + 3) = 2, 8, 8

**Question** The atomic number of Al and Cl are 13 and 17, respectively. What will be the number of electrons in Al3+ and Cl–?

**Answer** Atomic number of Al = Number of electrons = 13

Number of electrons in Al3+ = 13 – 3 = 10

Atomic number of chlorine = Number of electrons = 17

Number of electrons in Cl– = 17 + 1 = 18

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

**Answer** The electronic distribution of Cl is 2, 8, 7. The L shell has eight electrons.

**Question** Define valence electrons. Which electrons of an atom are involved in the chemical bond formation with other atoms?

**Answer** The electrons present in the outermost shell of an atom or ion are known as valence electrons.

In a chemical bond formation, only valence electrons of an atom take part.

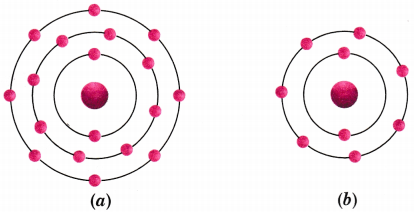
**Question** Why do helium, neon and argon have a zero valency?

**Answer** Helium has two electrons in its energy shell, while argon and neon have 8 electrons in their valence shells. As these 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.

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

**Answer** Helium atom has 2 electrons in its valence shell and its duplet is complete. Hence, the valency is zero.

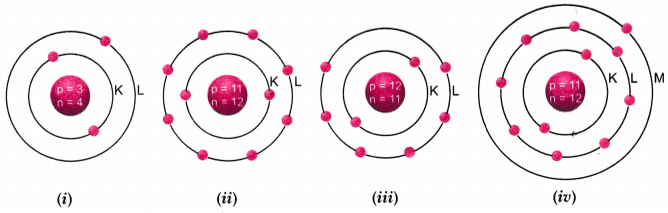
**Question** Find out the valency of the atoms represented by the Figs. (a) and (b)



**Answer** (a) 0

(b) 1

**Question** Identify the Na+ ion from the following figures. What is the valency of sodium atom? Give reason.



**Answer** Figure number (ii) is correct because sodium ion (Na+) is formed when one electron is lost.

Na ⟶ Na++1e−

(2,8,1) (2,8)

The valency of sodium atom is one because stable (octet) electronic configuration is obtained after loss of one electron.

**Question** Calculate the number of neutrons present in the nucleus of an element X which is represented as 

**Answer** Mass number = No. of protons + No. of neutrons = 31

∴ Number of neutrons = 31 – Number of protons

= 31 – 15 = 16

**Question** Why do isotopes show similar chemical properties?

**Answer** Isotopes have same atomic numbers and thus same number of electrons. Therefore, they have the same electronic configuration which provides them similar chemical properties.

**Question** An element ‘X’ has a valency 3(+):

(a) Write the formula of its phosphide.

(b) Write the formula of its carbonate.

**Answer** (a) XP

(b) X2 (CO3)3

**Question** An element ‘Z’ forms the following compound when it reacts with hydrogen, chlorine, oxygen and phosphorous.

ZH3, ZCl3, Z2O3 and ZP

(a) What is the valency of element ‘Z’?

(b) Element ‘Z’ is metal or non-metal?

**Answer** (a) The valency of ‘Z’ is 3.

(b) Element ‘Z’ is a metal because it is electropositive and is reacting with non-metals.

**Question** List any three distinguishing features between the models of an atom proposed by J.J. Thomson and Ernest Rutherford.

**Answer**

|  |  |
| --- | --- |
| **J. J. Thomson Model of Atom** | **Rutherford’s Model** |
| 1. Positive charge forms a kernel. | 1. Nucleus (positive charge) is in the centre. |
| 2. Electrons present throughout the atom. | 2. Electrons revolve in orbits. |
| 3. No space is empty. | 3.Most of the space is empty. |

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

**Answer** % of α-particles deflected more than 50° = 1% of a-particles.

% of α-particles deflected less than 50° = 100 – 1 = 99%

Number of particles that deflected at an angle less than 50°

= 99100×6.022×1023

= 596.178100×1023

= 5.96 × 1023

**Question** Predict the valency of the following elements

(i) A (Atomic number 5)

(ii) B (Atomic number 12)

(iii) C (Atomic number 14)

(iv) D (Atomic number 17)

**Answer** (i) Valency of element ‘A’ = 8 – 5 = 3

(ii) Valency of element ‘B’ = 12 – 10 = 2

(iii) Valency of element ‘C’= 14 – 10 = 4

(iv) Valency of element ‘D’= 18 – 17 = 1

**Question** An element ‘X’ contains 6 electrons in ‘M’ shell as valence electrons:

(a) What is the atomic number of ‘X’?

(b) Identify whether ‘X’ is a metal or non-metal.

**Answer** (a) If ‘X’ contains 6 electrons in ‘M’ shell as valence electrons, then the electronic configuration of‘X’ is K = 2, L = 8, M = 6

∴ Atomic number = 16

(b) ‘X’ is a non-metal.

**Question** The atomic number of lithium is 3. Its mass number is 7.

(a) How many protons and neutrons are present in a lithium atom?

(b) Draw the diagram of a lithium atom.

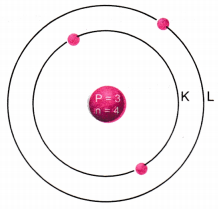
**Answer** (a) Number of neutrons = Mass number – atomic number

Number of neutrons = 7 – 3 = 4

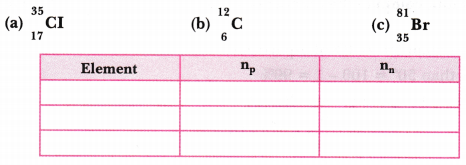
Number of protons = atomic number

∴ Number of protons = 3

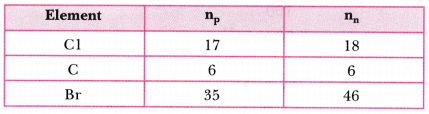
(b) Structure of a lithium atom



**Question** Complete the table on the basis of information available in the symbols given below



**Answer**



**Question** In the atom of an element ‘Z’, 5 electrons are present in the outermost shell. It requires noble gas configuration by accepting requisite number of electrons, then what would be the charge on the ion so formed? Write the formula of the compound which will be formed when ‘Z’ reacts with Na atom.

**Answer** Number of electrons in the outermost shell = 5

Number of electrons required to make noble gas configuration = 8 – 5 = 3

The charge on the ion so formed = Z + 3e–= Z3-

The valency of Z = 3

Chemical formula of the compound:



**Question**  is an isotope of noble gas, radon. How many protons, neutrons and electrons are there in one atom of this radon isotope?

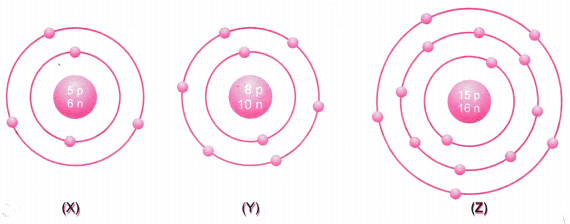
**Answer** Atomic number of radon = 86

The number of protons = 86

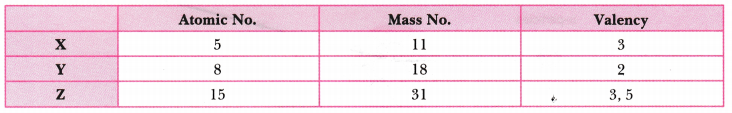
The number of electrons = Number of protons = 86

Number of neutrons = Atomic mass – Atomic number = 222 – 86 = 136

**Question** What information do you get from the figures about the atomic number, valency of atoms X, Y and Z? Give your **Answer** in a tabular form.



**Answer**



**Question** Write the molecular formulae for the following compounds:

(a) Copper (II) bromide

(b) Aluminium (III) nitrate

(c) Calcium (II) phosphate

(d) Iron (III) sulphide

(e) Mercury (II) chloride

(f) Magnesium (II) acetate

**Answer** (a) CuBr2

(b) Al(NO3)3

(c) Ca3(PO4)2

(d) Fe2S3

(e) HgCl2

(f) Mg(CH3COO)2

**Question** Write the molecular formulae of all the compounds that can be formed by the combination of following ions

Cu2+, Na+, Fe3+, Cl–, so2−4,PO3−4

**Answer** CuCl2; CuSO4; Cu3 (PO4)2

NaCl; Na2SO4; Na3PO4

FeCl3; Fe2(SO4)3; FePO4

**Question** Write the formula of the compounds formed by the following ions.

(a) Mg2+ and S2-

(b) Cu2+ and OH

Name the compounds formed in each case.

**Answer** (a) Ions Mg2+ S2-

Valencies 2 2

Compound: Mg2S2 or MgS; Magnesium sulphate

(b) Ions Cu2+ OH–

Valencies 2 1

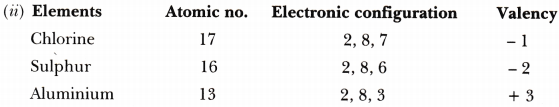
Compound: Cu(OH)2; Copper (II) hydroxide.

**Question** (i) State the method of determining the valency of an element if its atomic number is given.

(ii) Determine the valency of the following elements, the atomic numbers of which are given in parenthesis:

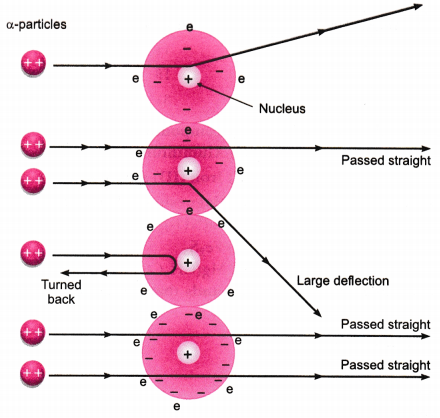
Chlorine (17), Sulphur (16), Aluminium (13)

**Answer** (i) The number of electrons gained, lost or shared to make the octet of electrons (in the outermost shell), gives us directly the combining capacity of the element, that is, the valency.



**Question** What is the gold foil experiment? Name the scientist who performed this experiment. Write the conclusions and shortcomings of Rutherford’s model of atom.

**Answer** In 1911, Rutherford performed the gold foil experiment. He bombarded a stream of a-particles on a gold foil, a thin sheet which was 0.00006 cm thick in an evacuated chamber. An a-particle is a positively charged helium ion (He2+). A simplified picture of this experiment is shown in the figure.

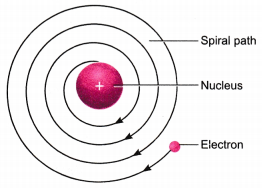


In this famous experiment, the following observations were made.

* Most of the a-particles passed straight through the foil without any deflection. This concluded that most of the space inside of an atom is empty.
* A few α-particles were deflected through small angle and few through larger angles. This happened due to positive charge on a-particles and core (nucleus) of the atom. The heavy positively charged ‘core’ was named as nucleus.
* The number of α-particles which bounced back was very small. This concluded that the volume of the nucleus is very small in comparison to the total volume of the atom.

On the basis of gold foil experiment, Rutherford concluded that an atom consists of nucleus which has positive charge and it is surrounded with electrons which are moving around the nucleus. The number of electrons and protons are equal and the entire mass of the atom is concentrated at its nucleus.

**Drawbacks in the Rutherford’s model**



* According to classical electro-magnetic theory, a moving charged particle, such as an electron under the influence of attractive force loses energy continuously in the form of radiations. As a result of this, electron should lose energy and therefore, should move in even smaller orbits ultimately falling into the nucleus. But the collapse does not occur. There is no explanation for this behaviour.
* Rutherford did not specify the number of orbits and the number of electrons in each orbit.

**Question** In what way is the Rutherford’s atomic model different from that of Thomson’s atomic model?

**Answer** Rutherford proposed a model in which electrons revolve around the nucleus in well-defined orbits. There is a positively charged centre in an atom called the nucleus. He also proposed that the size of the nucleus is very small as compared to the size of the atom and nearly all the mass of an atom is centred in the nucleus. Whereas, Thomson proposed the model of an atom to be similar to a Christmas pudding. The electrons are studded like currants in a positively charged sphere like Christmas pudding and the mass of the atom was supposed to be uniformly distributed.

**Question** What are the postulates of Bohr’s model of an atom?

**Answer** The postulates put forth by Neils Bohr’s about the model of an atom:

* Only certain special orbits known as discrete orbits of electrons, are allowed inside the atoms.
* While revolving in discrete orbits the electrons do not radiate energy. These orbits are called energy levels. Energy levels in an atom are shown by circles.  
  These orbits are represented by the letters K, L, M, N, … or the numbers n = 1, 2, 3, 4, ………..

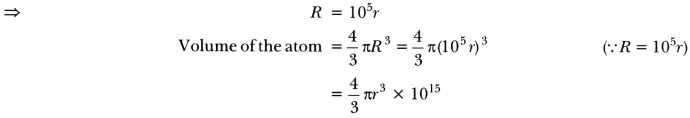
**Question** The ratio of the radii of hydrogen atom and its nucleus is ~105. Assuming the atom and the nucleus to be spherical,

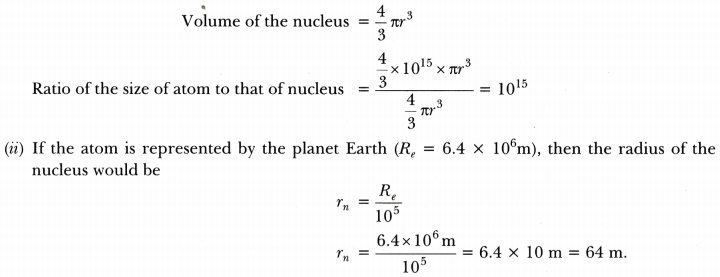
(i) what will be the ratio of their sizes?

(ii) If atom is represented by planet Earth ‘Re’ = 6.4 × 106 m. Estimate the size of the nucleus.

**Answer** (i) Volume of the sphere = 43 πr3

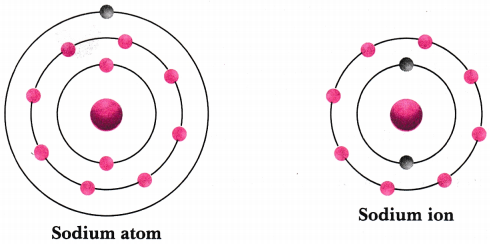
Let R be the radius of the atom and r be that of the nucleus.





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

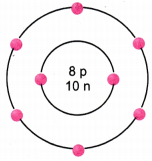
**Answer**



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

**Question** The given figure depicts the atomic structure of an atom of an element ‘X’.

Write the following information about the element ‘X’.



(a) Atomic number of ‘X’

(b) Atomic mass of ‘X’

(c) Valence electrons

(d) Valency of ‘X’

(e) ‘X’ should be metal or non-metal.

**Answer** (a) Atomic number = Number of protons = 8

(b) Atomic mass = Number of protons + Number of neutrons = 8 + 10 = 18 u

(c) Valence electrons = 6

(d) Valency of ‘X’ = 8 – 6 = 2

(e) ‘X’ should be non-metal because there are six valence electrons hence it will take two more electrons to complete its outermost shell.

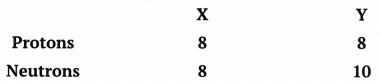
**Question** One electron is present in the outermost shell of the atom of an element ‘Z’.  
(a) What will be the nature of this element?

(b) What will be the value of charge of the ion formed, if this electron is removed from the outermost shell?

**Answer** (a) Element ‘Z’ will be a metal because it has only one electron in the outermost shell, so it is electropositive.

(b) After loss of one electron, ‘Z’ will acquire one positive charge. Z → Z+ + 1 e–

**Question** Composition of the nuclei of two atomic species ‘X’ and ‘Y’ are given below:



Give the mass number of ‘X’ and ‘Y’. What is the relationship between the two species?

**Answer**

(i) Atomic mass of element ‘X’ = Number of protons + Number of neutrons = 8 + 8 = 16 u

(ii) Atomic mass of element ‘Y’ = Number of neutrons + Number of protons = 10 + 8 = 18 u

Relationship between X and Y: The atomic number of both the elements is same but their atomic masses are different. Hence,they are isotopes of each other.

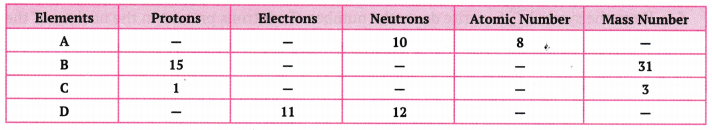
**Question** An atom ‘M’ of an element reacts with oxygen to form M2O3. Calculate the valency of the element ‘M’.

**Answer** Two atoms of element ‘M’ combine with 3 atoms of oxygen.

∴ Number of oxygen atoms combining with one atom of element ‘M’ = 32

Therefore, the valency of element ‘M’ = 32 × 2 = 3

**Question** Complete the following gaps in the given table:

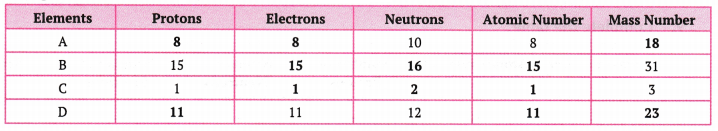


**Answer** We know that the number of protons = Atomic number

Number of protons = Number of electrons

Mass number = Number of protons + number of neutrons

Using these relationships, we can fill up these gaps as follows:



**Question** Explain why chlorine, whether as the element or its compounds, always has relative atomic mass of about 35.5.

**Answer** The relative atomic mass is the average mass of one of the atoms and has to take into account the relative abundances of the various isotopes.

Natural chlorine always contains about 34×3517Cl and 14×3717Cl.

Therefore, relative atomic mass of chlorine = 34×35+14×37 = 35.5 u

**Question** An element ‘X’ has mass number 4 and atomic number 2. Write the valency of this element. Will it react with other atoms of different elements?

**Answer** We know that only valence electrons take part in bond formation with different atoms. In the atom of ‘X’ element there are only two electrons since atomic number is 2. Thus, K shell is fully filled for this atom. Hence, its valency is zero. It will not react with other atoms of different elements.

**Question** How many electrons will weigh 1 g?

**Answer**  Mass of an electron = 9.11 × 10-31 kg

∴ Mass of 9.11 × 10-31 kg = 1 electron

Now, mass of 1g, i.e., 10-31 kg will have 19.11×10−31 × 10-3 electrons = 1.098 × 1027 electrons.