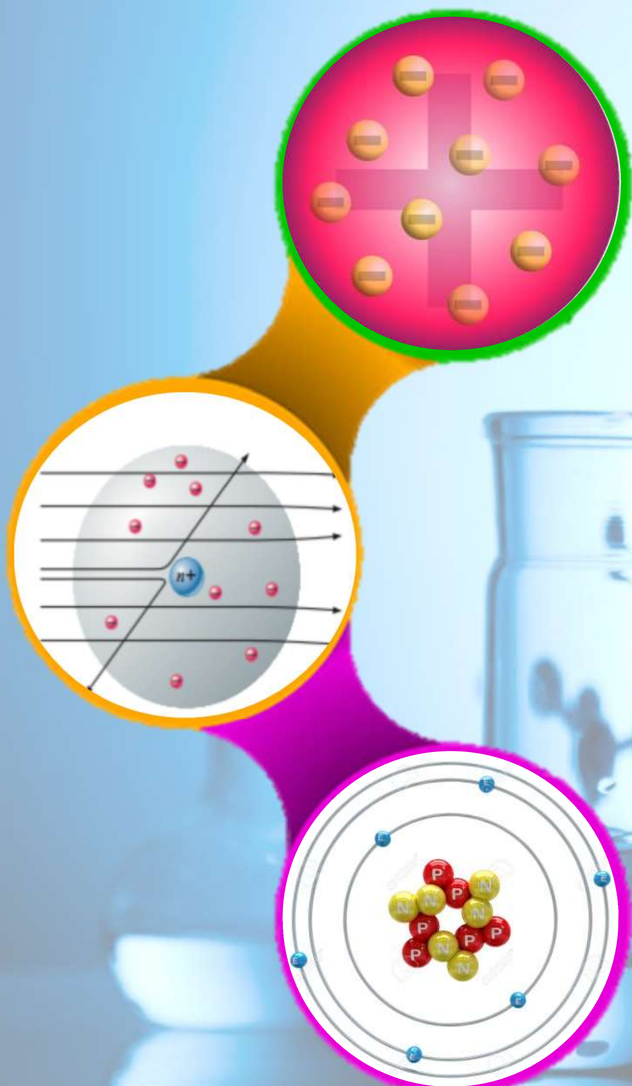
STRUCTURE OF THE ATOM



MODULE : 1

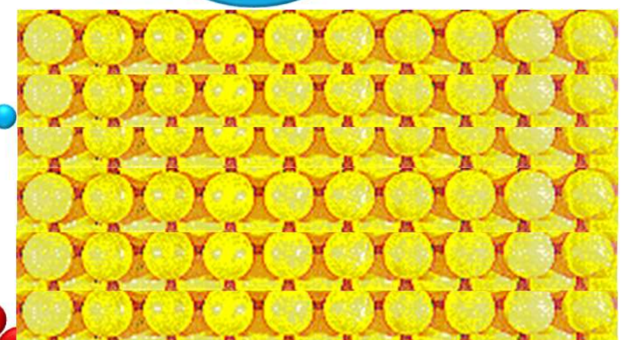
- **Introduction & activity**

We have learnt that atoms and molecules are the fundamental building blocks of matter

Are atoms really indivisible?

gold

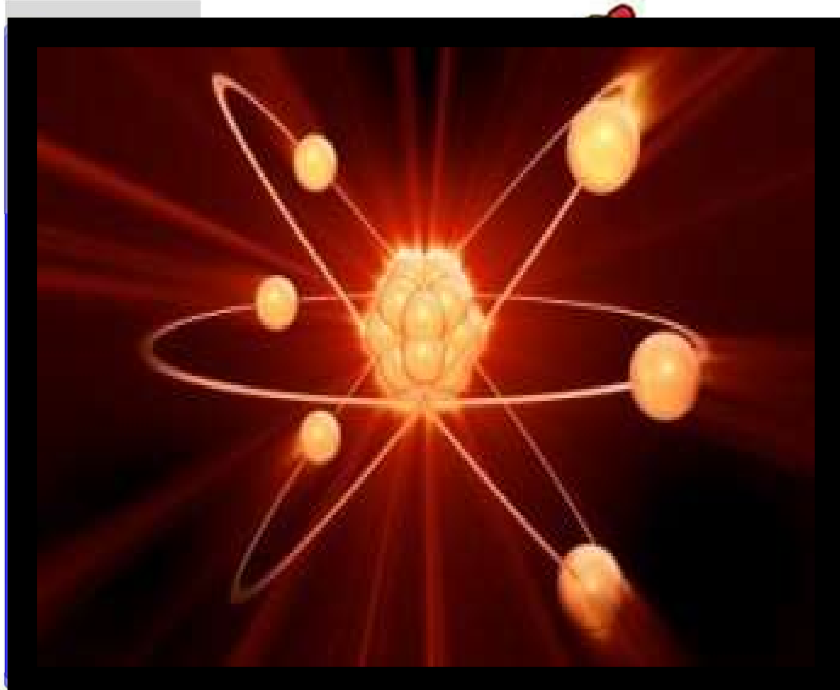
ld foil



What makes the atom of one element different from the atom of another element?

We shall find out the answers to these questions in this chapter

A C T I V I T Y



From these activities, can we

We know that an electrically

uncharged object.

electrically charged.

So, The atom is divisible.

Glass rod

simple experiments tell us

the charged particles

present in the atoms of mat

Small pieces Of paper

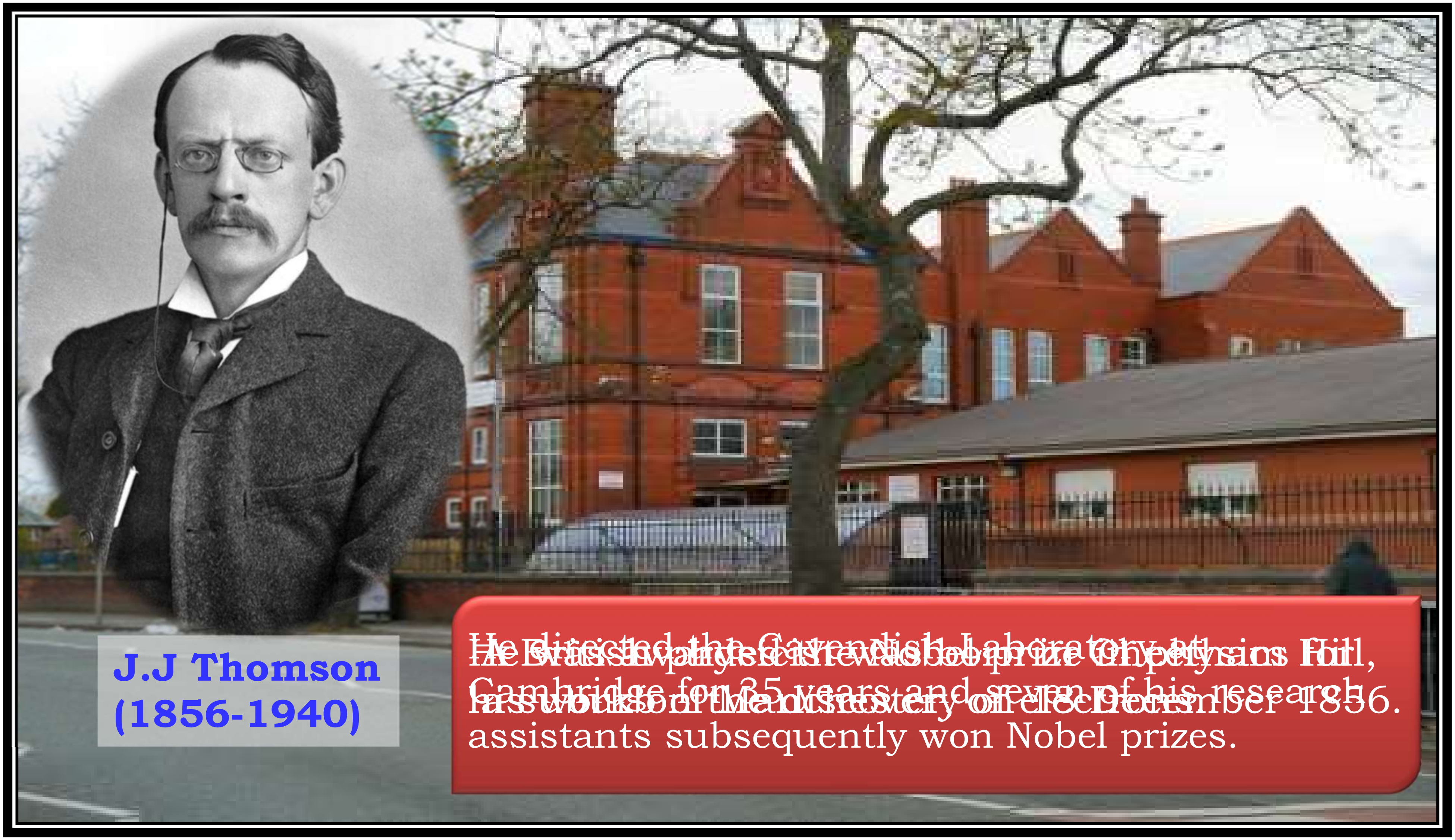
MODULE : 2

- **Discovery of Electrons & Thomson's atomic model**

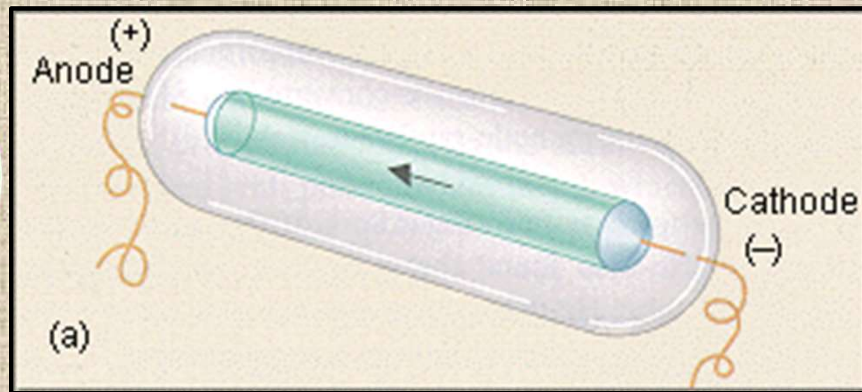
Many scientists contributed in revealing the presence of charged particles in an atom.

Discovery of sub-atomic particles

It was known by 1900 that the atom was not a simple, indivisible particles but Contained at least one sub - atomic particles.


J.J Thomson
(1856-1940)
He directed the Cavendish Laboratory at Cambridge for 35 years and seven of his research assistants subsequently won Nobel prizes.

THOMSON'S ATOMIC MODEL



Negative electrode

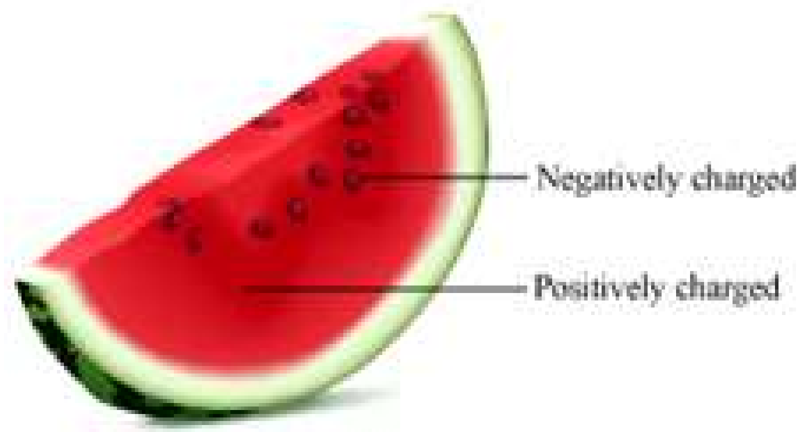
- Thomson passed electricity at high voltage through a gas at very low pressure taken in a discharge tube.
- Streams of minute particles were given out by the cathode.
- These streams of particles are called cathode rays.

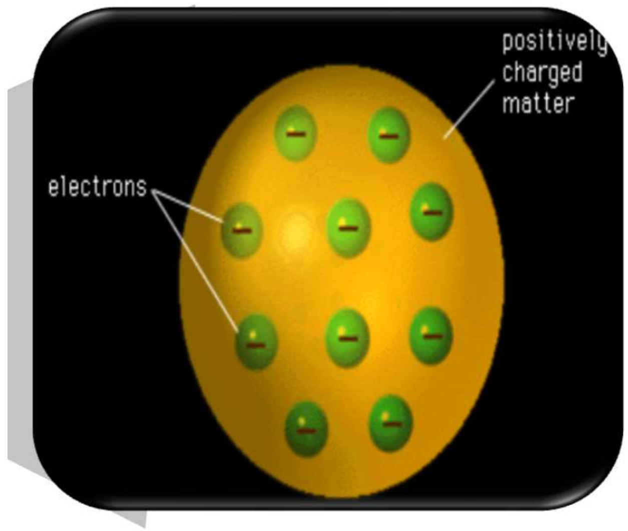
Because they come out of Cathode

- Cathode rays consist of small negatively charged part electrons.
- Since all the gases form cathode rays it was concluded that all the atoms contain negatively charged particles called electrons.

MODULE : 3

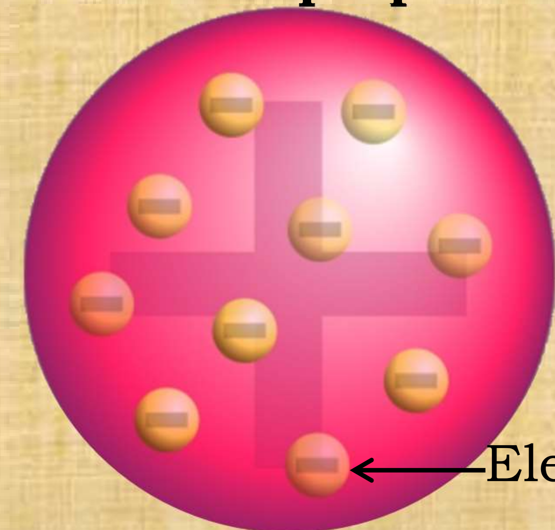
- **Canal rays, protons & characteristics**

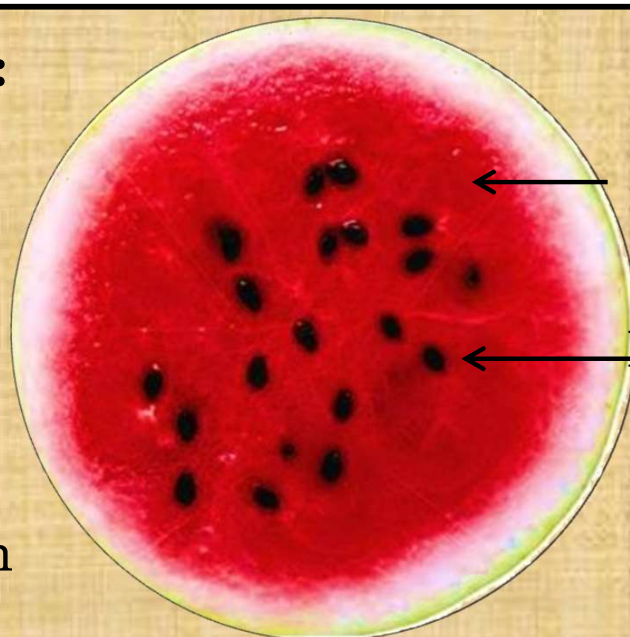




- Thomson proposed the model of an atom to be similar to that of a Christmas pudding.
- The electrons , in a sphere of positive charge. Were like a currants (dry fruits) in a spherical Christmas pudding.
- While the electrons are studded in the positively charged sphere, like the seeds in the watermelon.

Thomson proposed that:





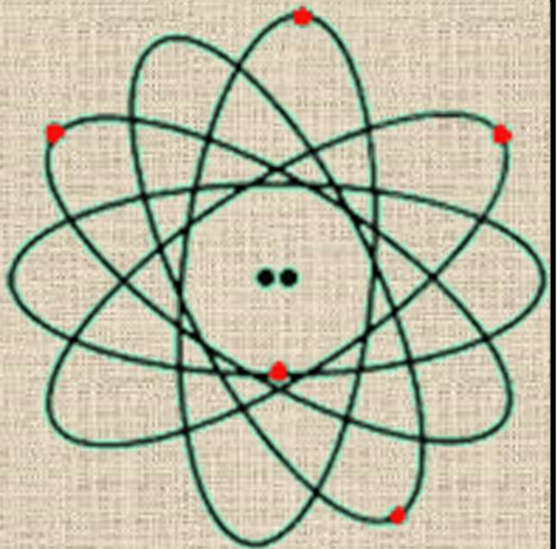
i) An atom consists of a positively charged sphere and the electrons are embedded in it.

ii) The negative and positive charges are equal in magnitude. So, the atom as a whole is electrically **Neutral.**

No charge

Characteristics of an Electron

Mass of an Electron



- The mass of an electron is about $\frac{1}{1840}$ of the mass of hydrogen atom
- The mass of an electron is so small that it is considered to be negligible.

Charge of an Electron

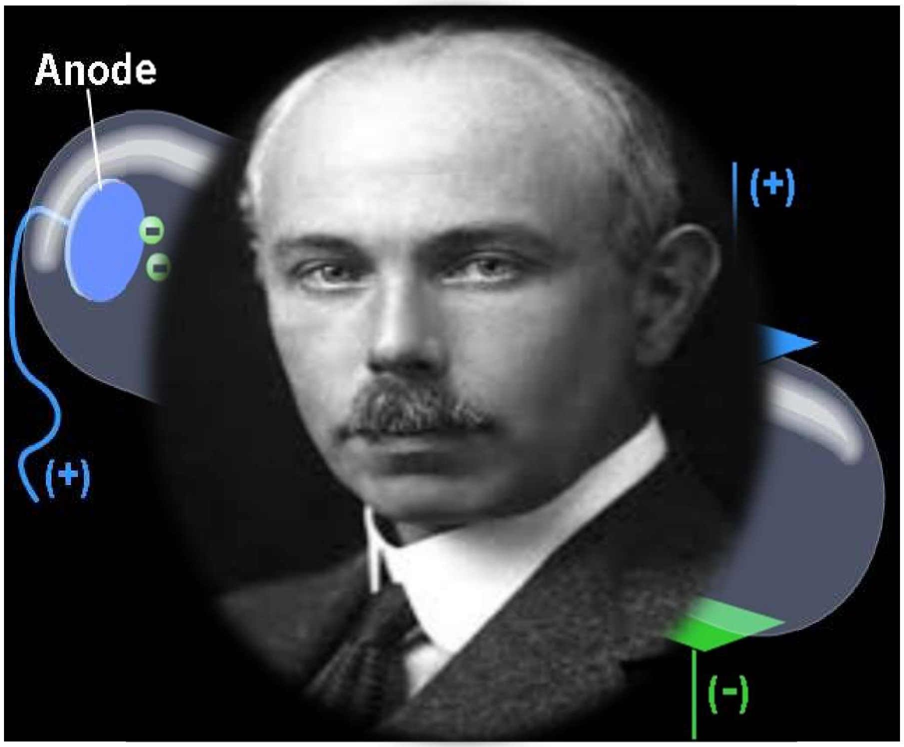
- The absolute charge on an electron is 1.6×10^{-19} coulomb of negative charge.
- The relative charge of an electron is, -1 (minus one).

MODULE : 4

- **Rutherford's gold foil experiment & drawback**

E. Goldstein discovered the presence of new radiations in a gas Discharge and called them canal rays.

These rays were positively charged radiations.



This sub-atomic particle had a charge, equal in magnitude but opposite in sign to that of the electron.

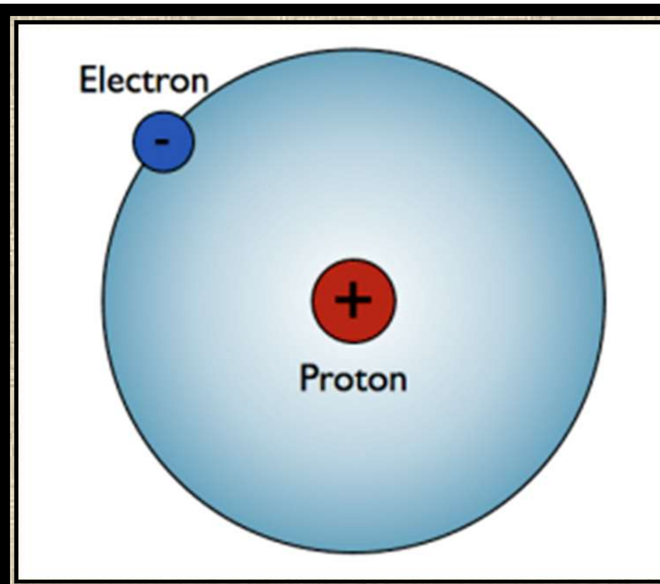
Its mass was approximately 2000 times as that of the electron.

It was given the name of **proton.**

Which is represented as ‘p’

Characteristics of a proton

The two important characteristics of a proton are its mass and charge.



Mass of a proton

- The proton is actually a hydrogen atom which has lost its electron.
- The relative mass of a proton is 1 u.

Charge of a proton

- The charge of a proton is equal and opposite to the charge of an Electron.
- So the absolute charge of a proton 1.6×10^{-19}coulomb of positive charge.
- In other words, the relative charge of a proton is + 1(plus one).

MODULE : 5

- **Neils Bohr's atomic model & electronic configuration**

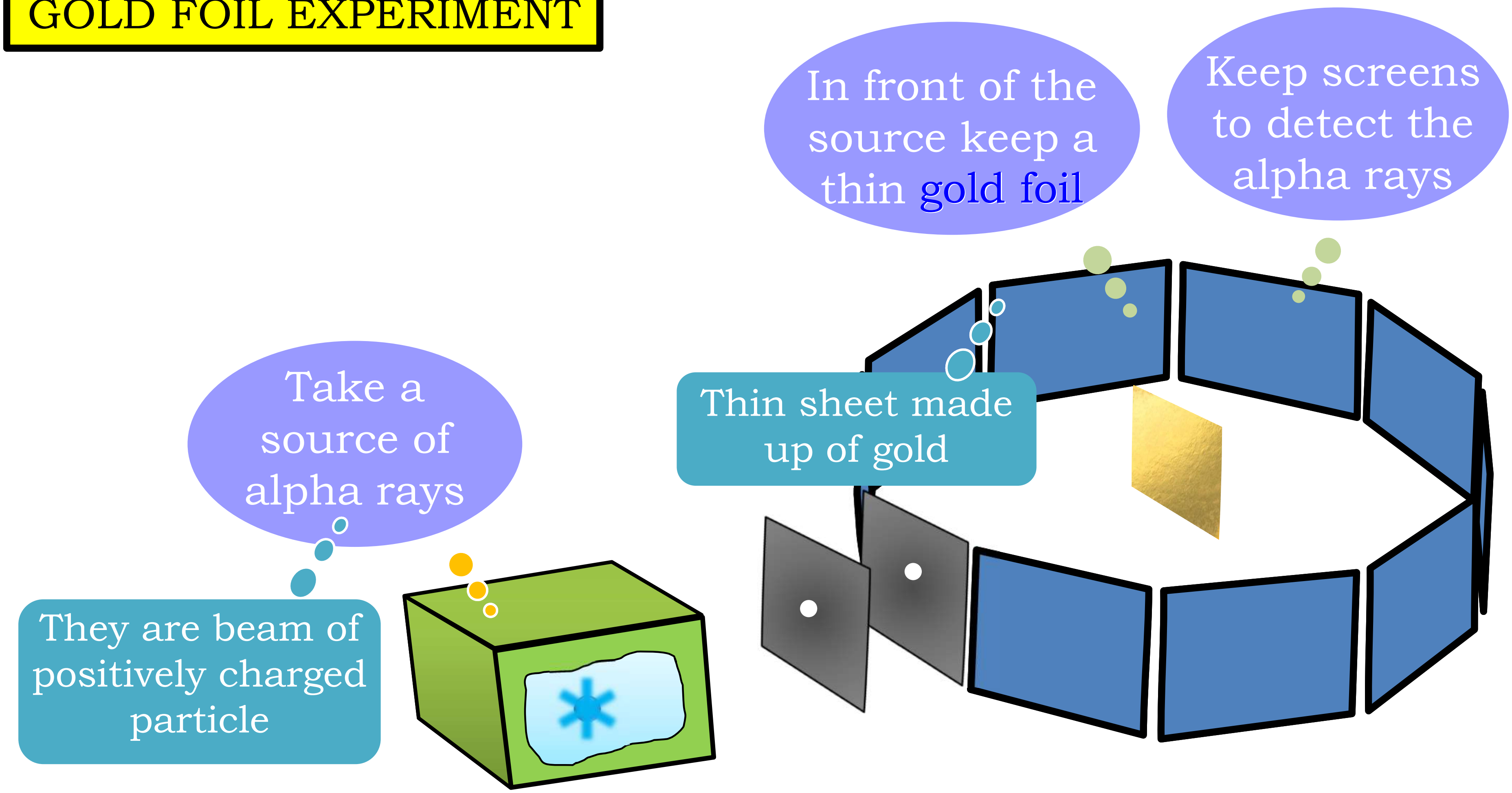

E. Rutherford
(1871-1937)
discovery of the nucleus of an atom
with the gold foil experiment.

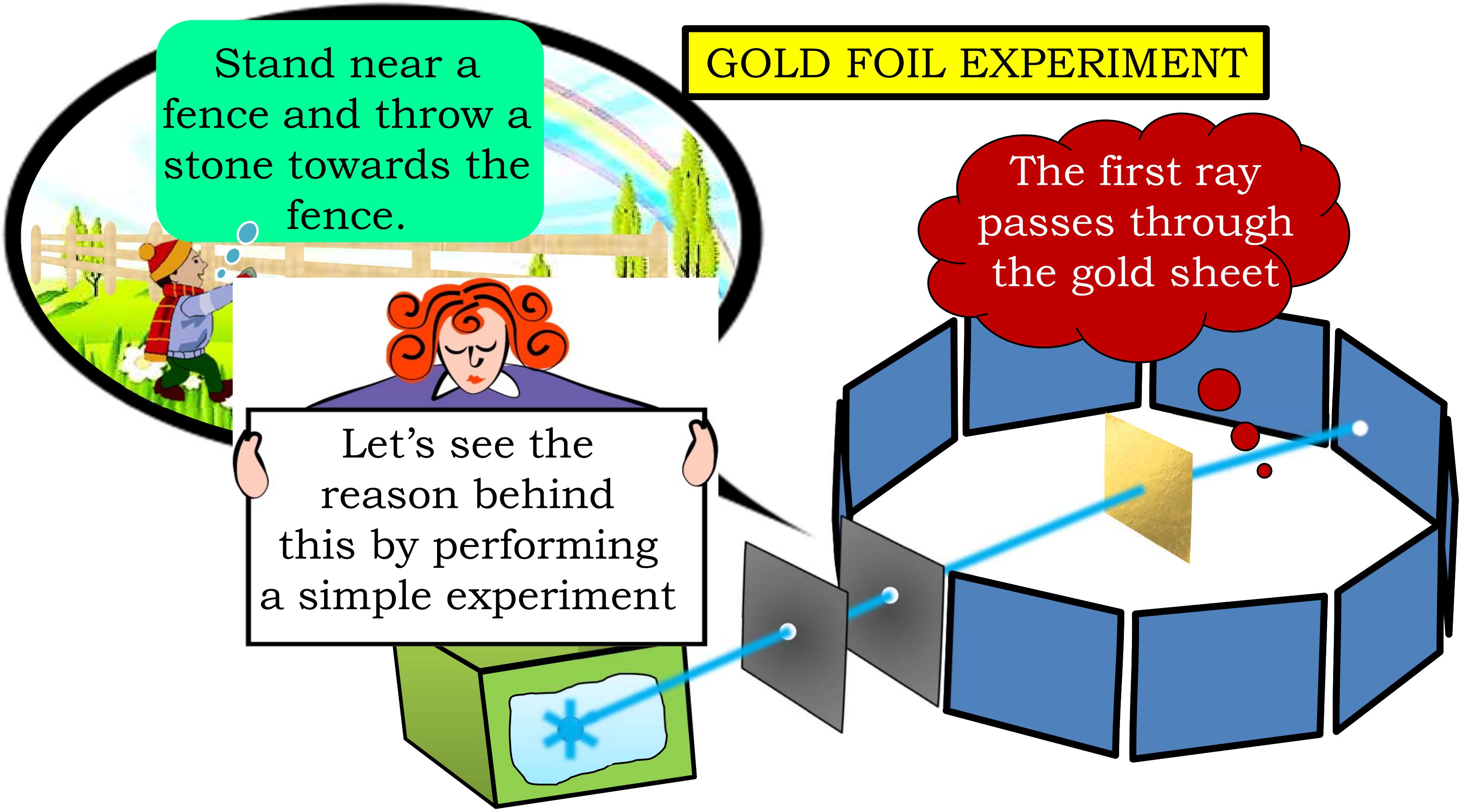
RUTHERFORD'S MODEL OF AN ATOM

Alpha particles is a positively charged particle having 2 units of positive charge & 4 units of mass

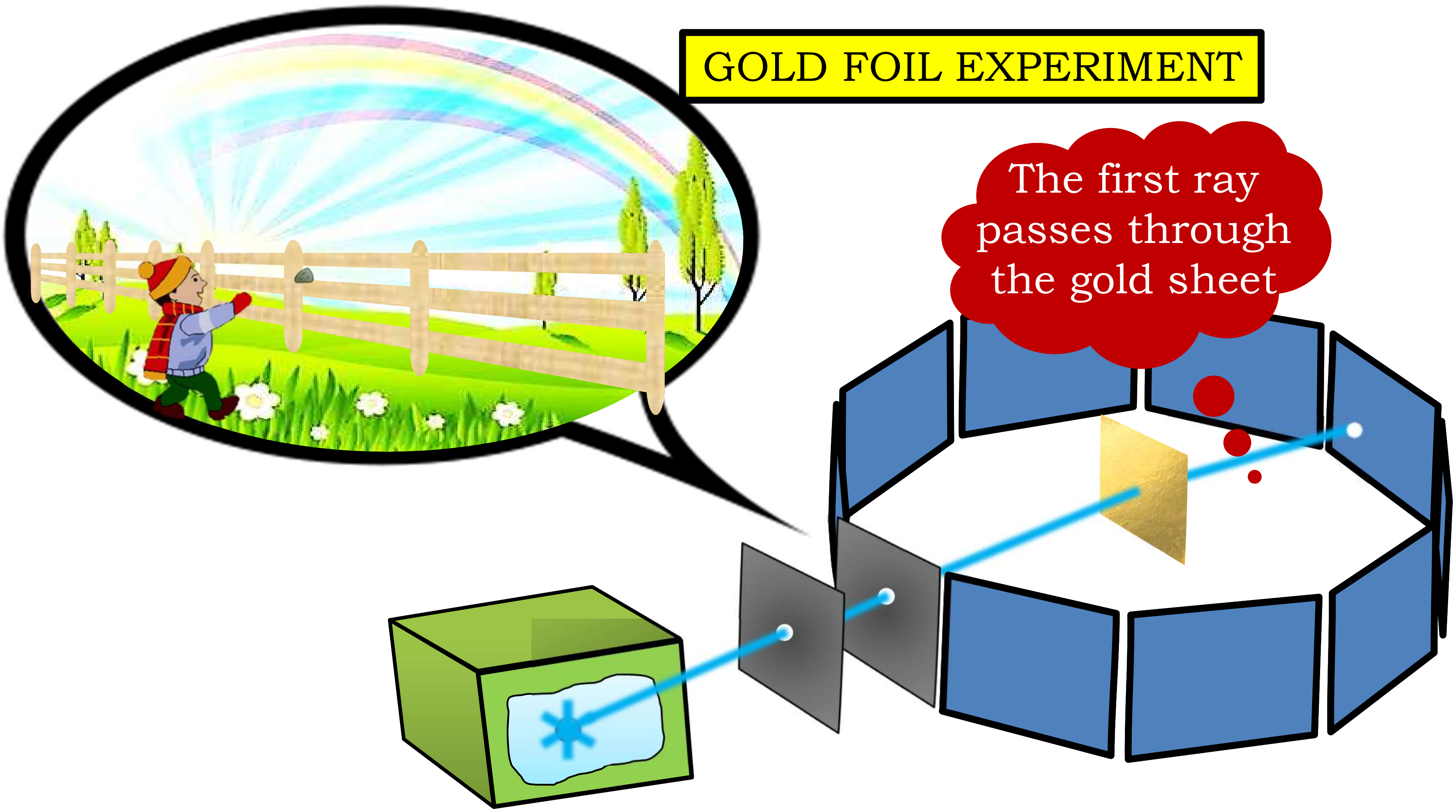
- Ernest Rutherford was interested in knowing how the electrons are arranged within an atom.
- Rutherford designed an experiment for this.
- In this experiment, fast moving alpha (∝) – particles were made to fall on a thin gold foil

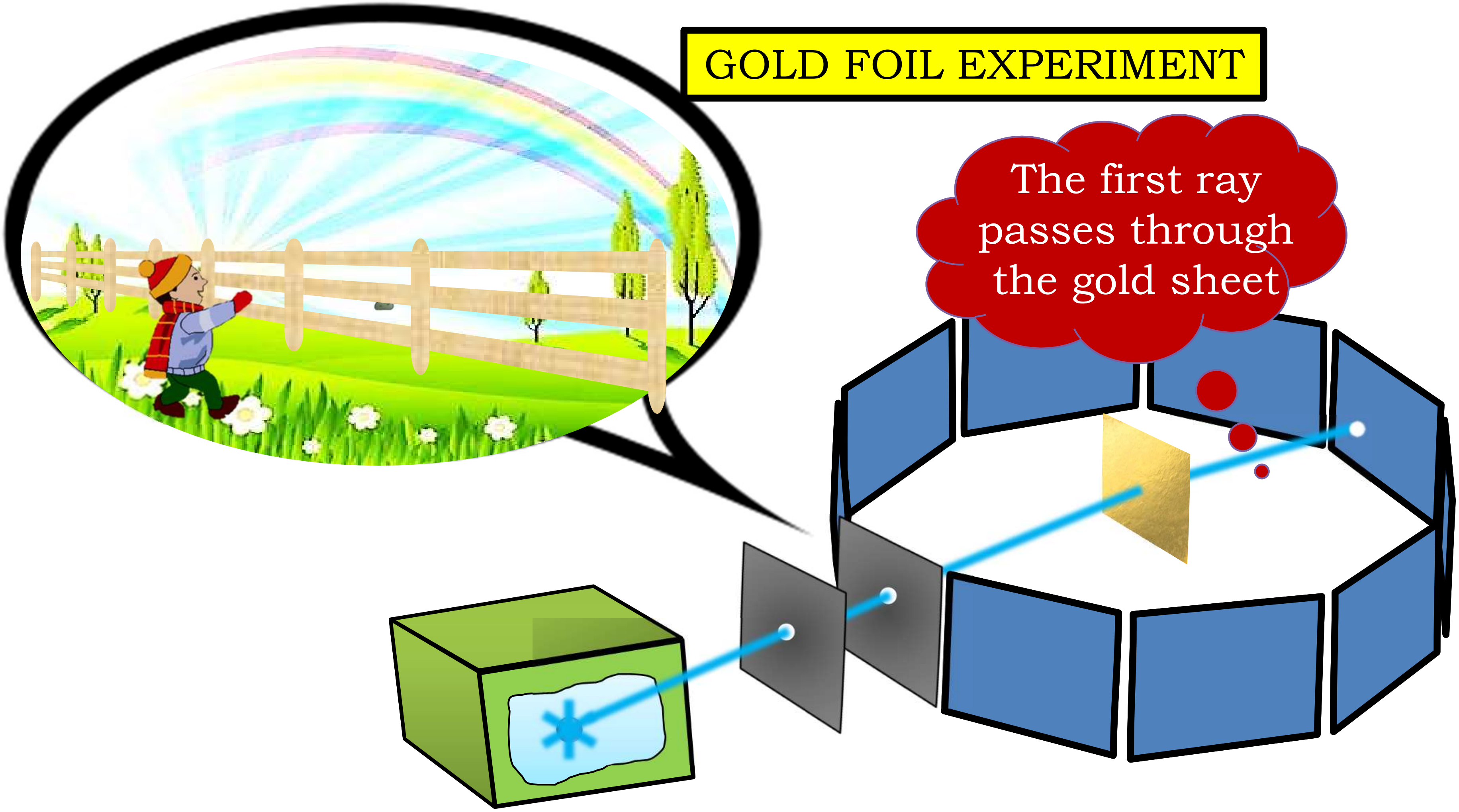
GOLD FOIL EXPERIMENT

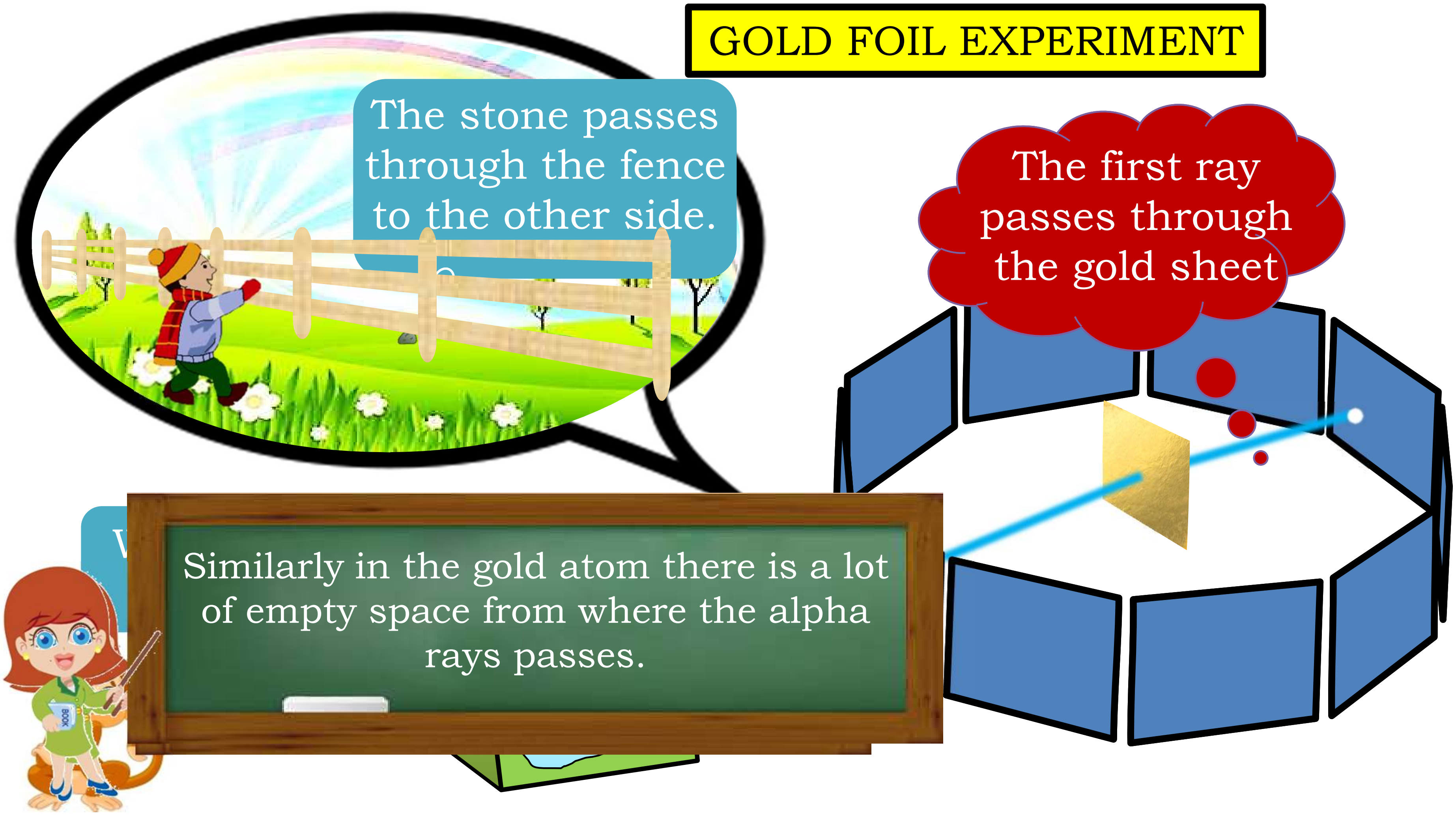


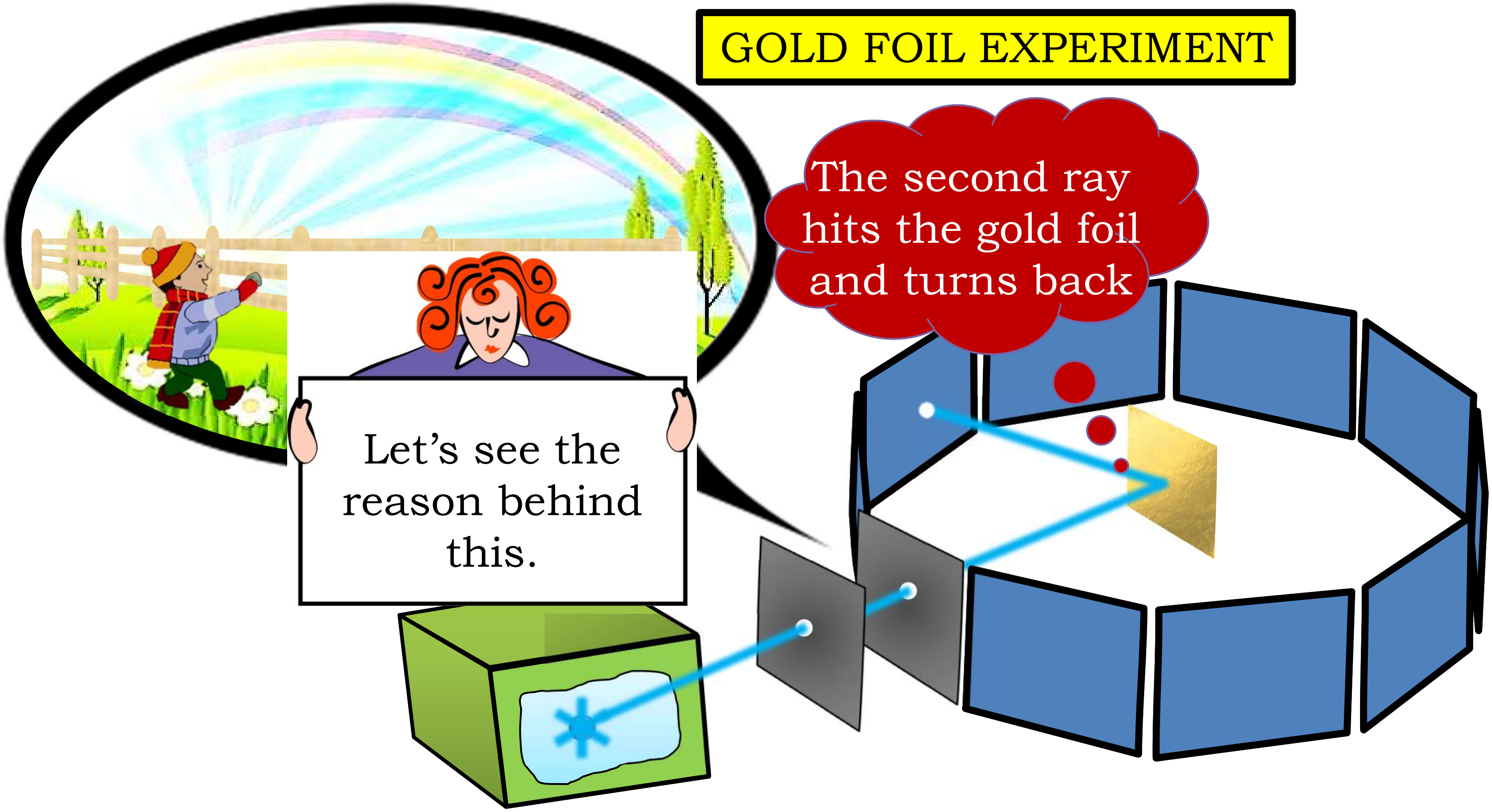


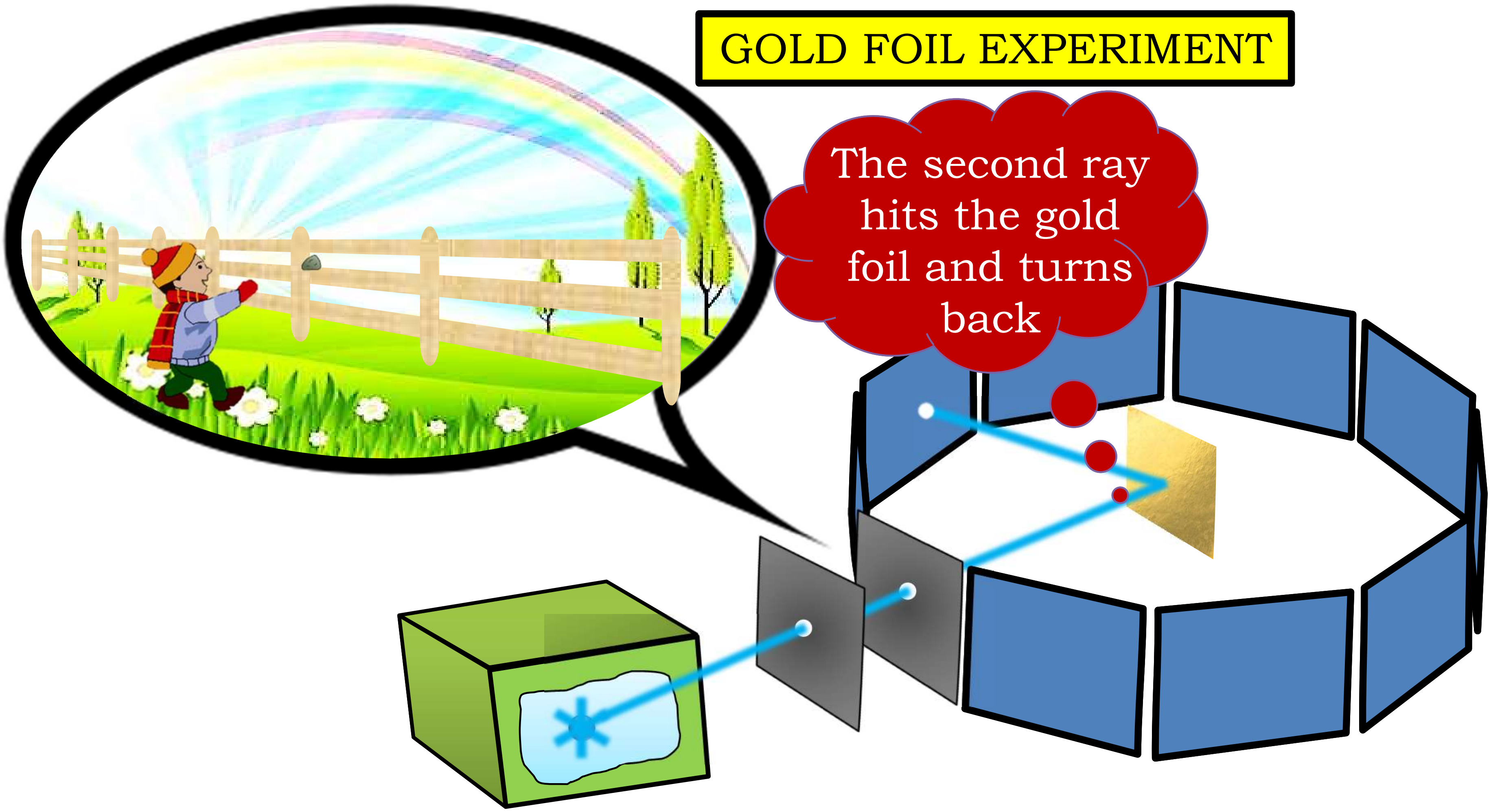
Stand near a fence and throw a stone towards the fence.
GOLD FOIL EXPERIMENT
The first ray passes through the gold sheet
Let's see the reason behind this by performing a simple experiment

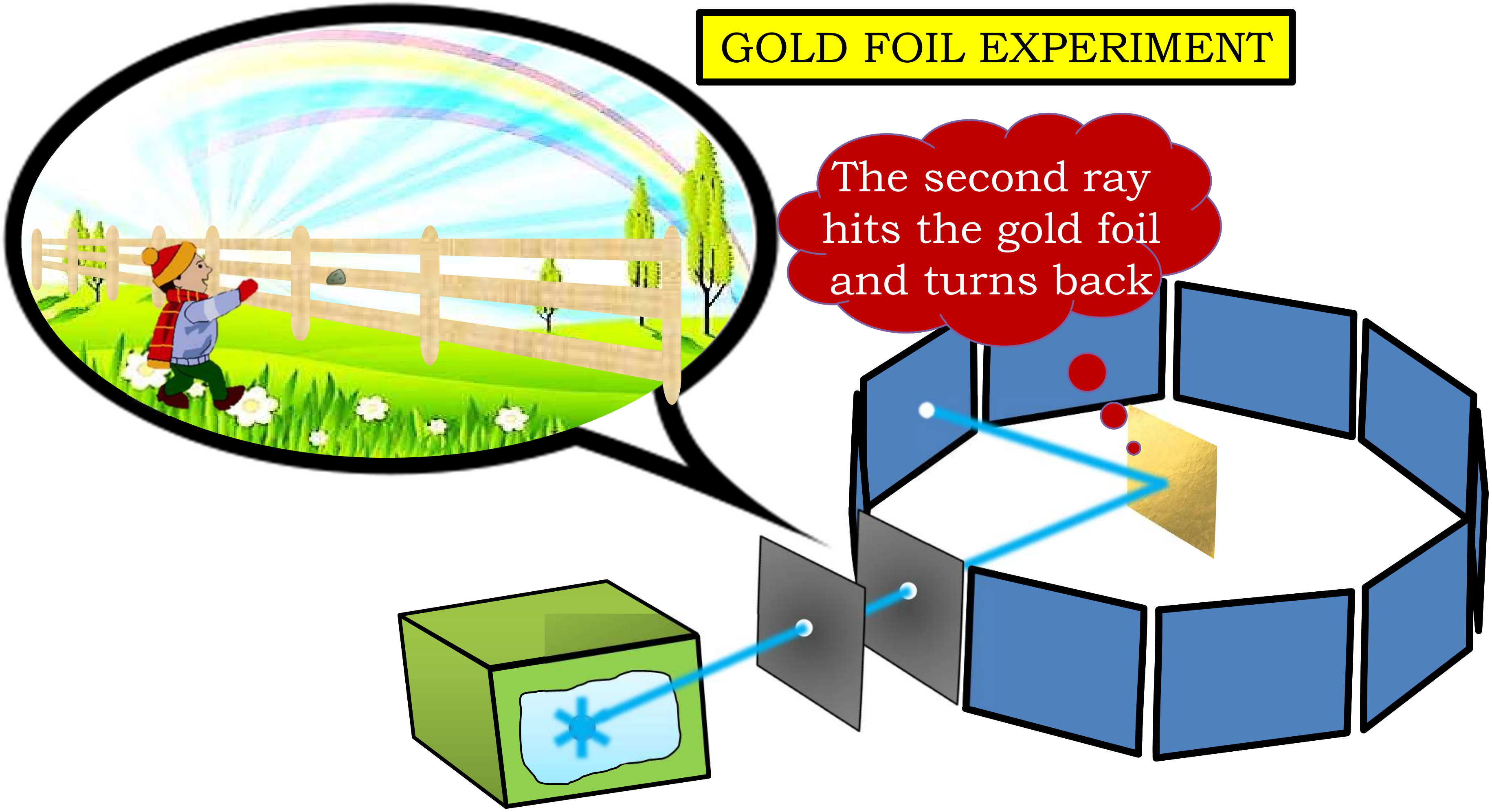

GOLD FOIL EXPERIMENT
The first ray passes through the gold sheet

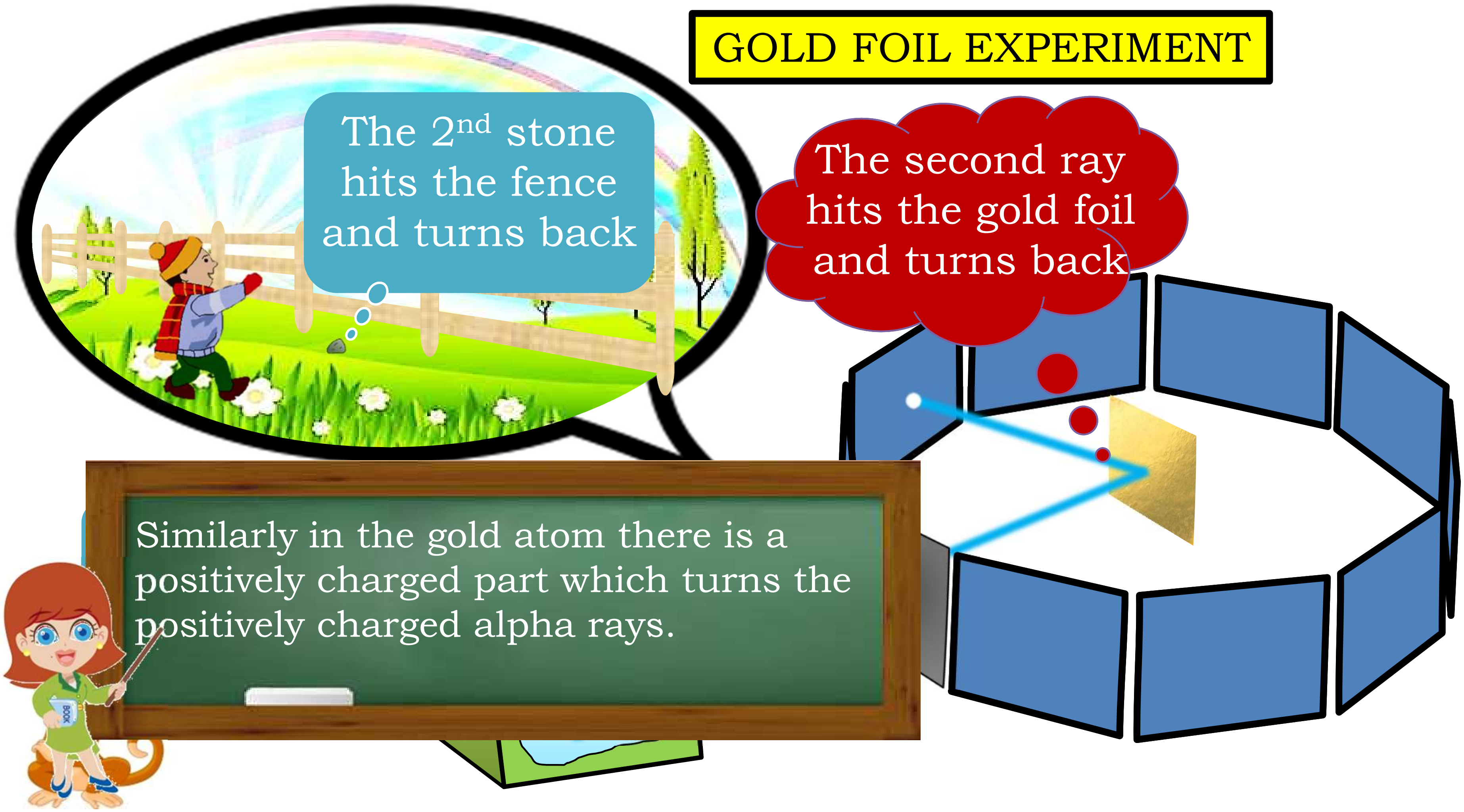

GOLD FOIL EXPERIMENT
The first ray passes through the gold sheet


GOLD FOIL EXPERIMENT
The stone passes through the fence to the other side.
The first ray passes through the gold sheet
Similarly in the gold atom there is a lot of empty space from where the alpha rays passes.


GOLD FOIL EXPERIMENT
The second ray hits the gold foil and turns back
Let's see the reason behind this.

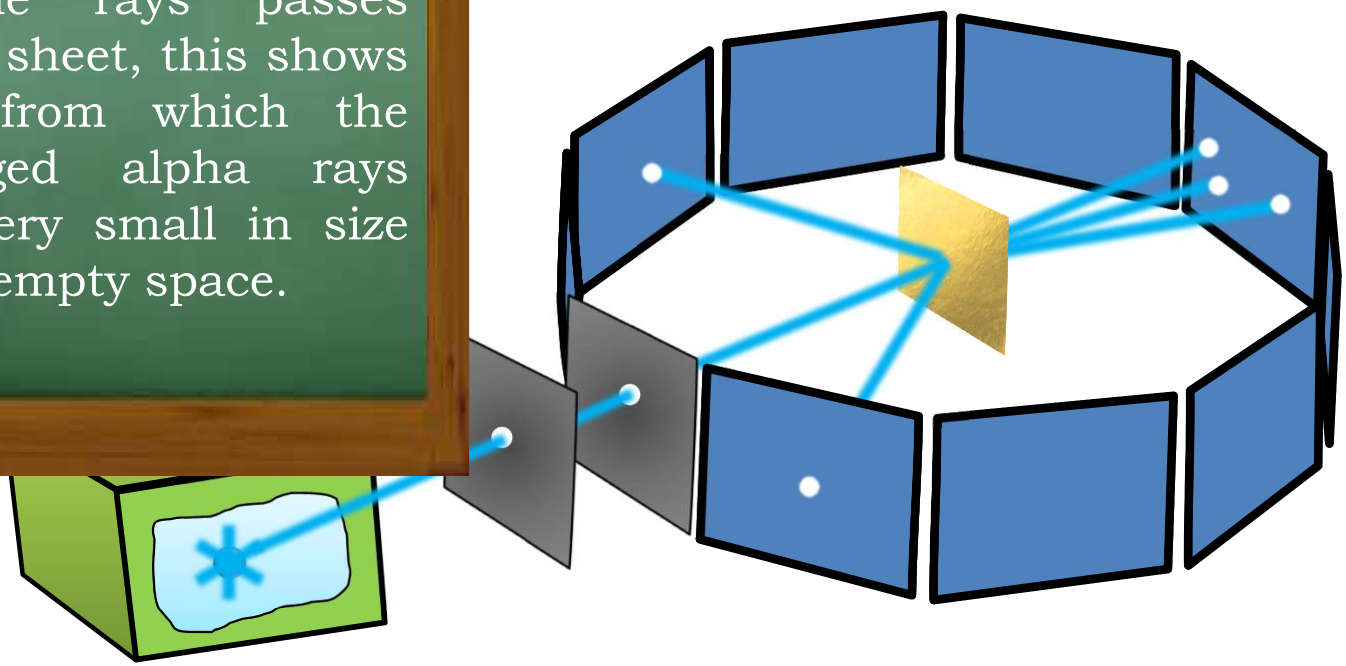

GOLD FOIL EXPERIMENT
The second ray hits the gold foil and turns back


GOLD FOIL EXPERIMENT
The second ray hits the gold foil and turns back


GOLD FOIL EXPERIMENT
The 2nd stone hits the fence and turns back
The second ray hits the gold foil and turns back
Similarly in the gold atom there is a positively charged part which turns the positively charged alpha rays.
BOOK

GOLD FOIL EXPERIMENT

Majority of the rays passes through the gold sheet, this shows that the part from which the positively charged alpha rays turns back is very small in size compared to the empty space.



Conclusion of Rutherford’s alpha- particle scattering experiment show the presence of a nucleus in the atom.

It also given the following important information about the nucleus of an atom:

The relative size of the nucleus in an atom is roughly the same As that of a pea in the middle of this large stadium.

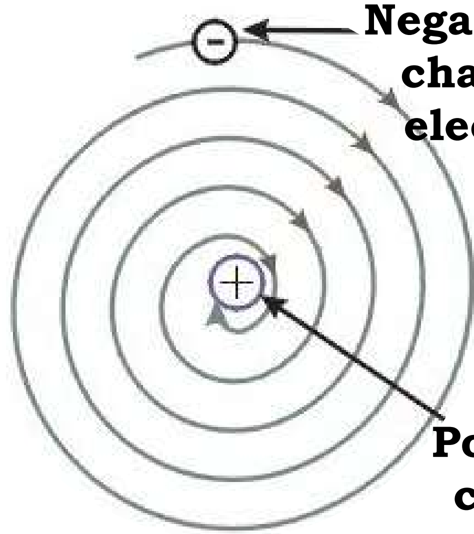
Drawback of Rutherford’s Model of the Atom

- A major drawback (or defect) of Rutherford’s model of the atom is that it does not explain the stability of the atom.

- Any particle in a circular orbit would undergo acceleration.

- During acceleration, charged particles would radiate energy.

- Thus, the revolving electron would lose energy and finally fall into the nucleus.



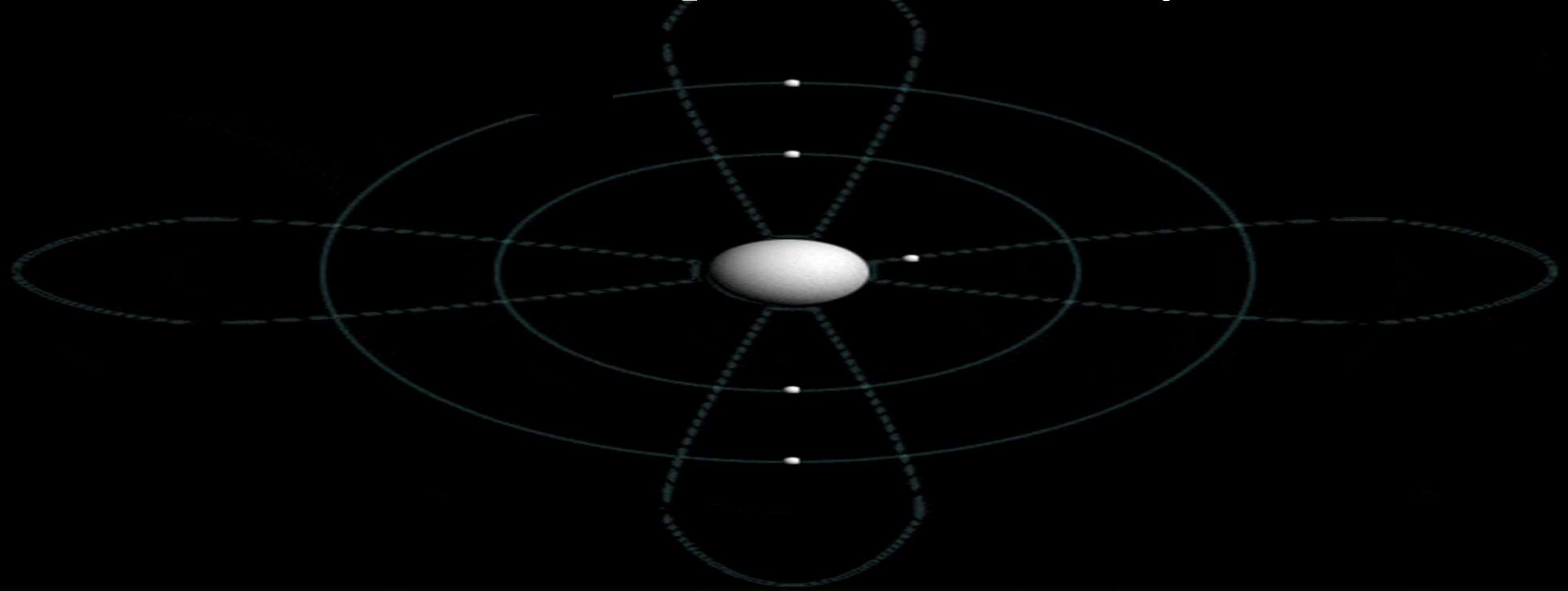
If this were so, the ato
unstable and hence f
in the form that we know

We know that atoms are quite stable.

MODULE : 6

- **Electronic Configuration of first 18 elements**

Neils Bohr Explained the stability of Atom



In order to explain the stability of atom and overcome the objection against Rutherford's model of atom, Neils Bohr gave a new arrangement of electrons in the atom in 1913.

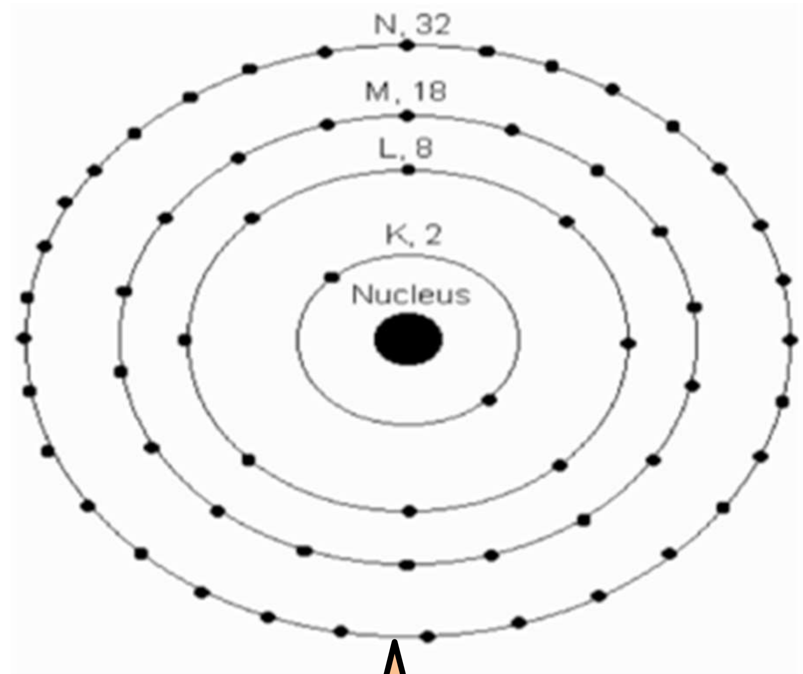

Neils Bohr
(1855-1962)
Three appearing as books are
iii) The Description of nature.

BOHR'S MODEL OF ATOM

In order to overcome the objections raised against Rutherford's model of the atom, Neils Bohr put forward the following postulates about the model of an atom:

1. Only certain special orbits known as discrete orbits of electrons, are allowed inside the atom.
2. While revolving in discrete orbits the electrons do not radiate energy.

These orbits or shells are represented by the letters K,L,M,N,... or the numbers, n = 1,2,3,4,...



These orbits or shell are called energy level.

There is a limit to the number of electrons which is energy level (or shell) can hold

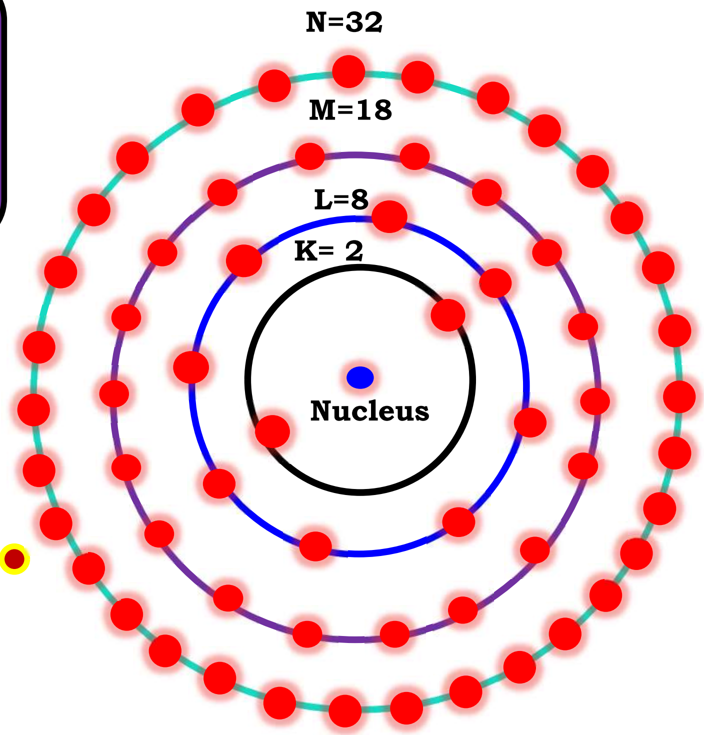
The maximum number of electrons which can be accommodated in any energy level of the atom is given by $2n^2$ (where n is the number of that energy level).

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

L shell $= 2\,(2)^2 = 8$

M shell $= 2\,(3)^2 = 18$

N shell $= 2\,(4)^2 = 32$

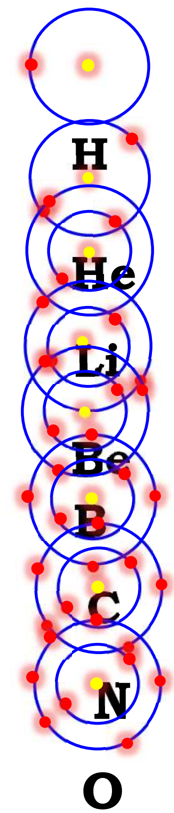


MODULE : 7

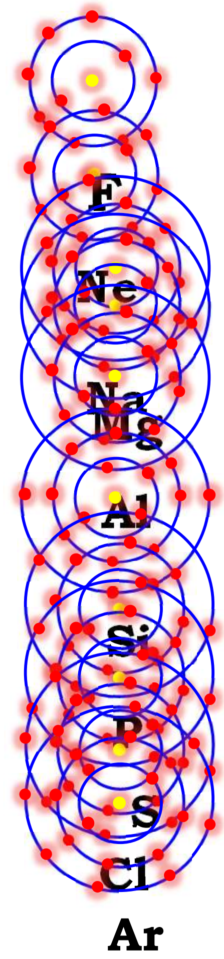
- **Discovery of Neutrons & characteristics**

Composition of Atoms of the first Eighteen Elements with Electron Distribution in Various Shells

Name of Element	Symbol	Atomic Number	Distribution of Electrons
Hydrogen	H	1	(1)
Helium	He	2	(2)
Lithium	Li	3	(2,1)
Beryllium	Be	4	(2,2)
Boron	B	5	(2,3)
Carbon	C	6	(2,4)
Nitrogen	N	7	(2,5)
Oxygen	O	8	(2,6)

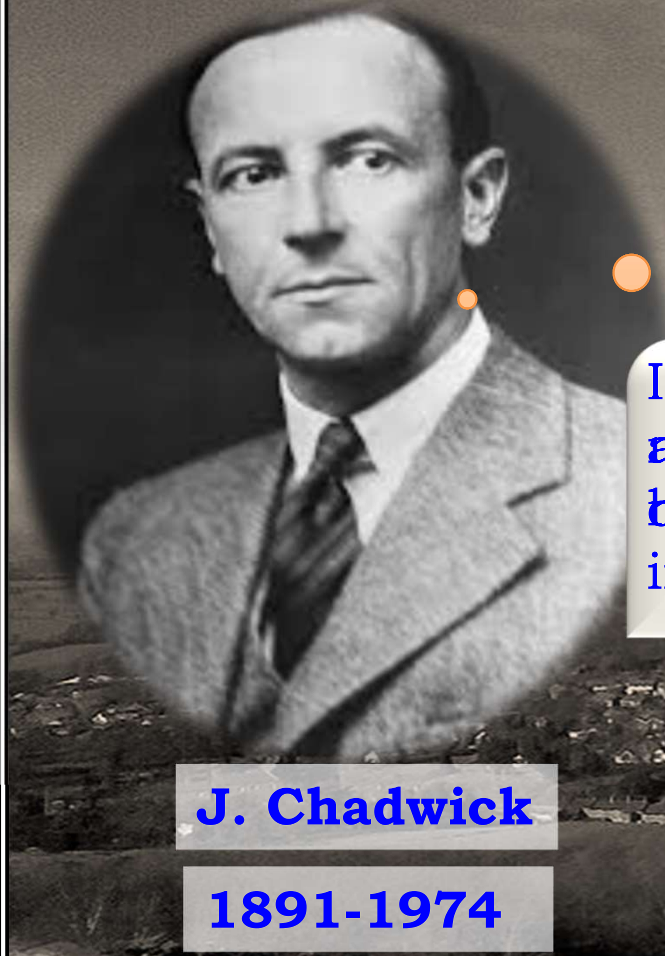


Name of Element	Symbol	Atomic Number	Distribution of Electrons
Fluorine	F	9	(2,7)
Neon	Ne	10	(2,8)
Sodium	Na	11	(2,8,1)
Magnesium	Mg	12	(2,8,2)
Aluminium	Al	13	(2,8,3)
Silicon	Si	14	(2,8,4)
Phosphorus	P	15	(2,8,5)
Sulphur	S	16	(2,8,6)
Chlorine	Cl	17	(2,8,7)
Argon	Ar	18	(2,8,8)



MODULE : 8

- **Atomic number & Mass number**



Chadwick was born in Bolington,Cheshire, on 20 October 1891

In 1932, J. Chadwick discovered neutrons. [illegible] mass nearly equal to that of a proton.

[illegible] protons and neutrons present in the nucleus.

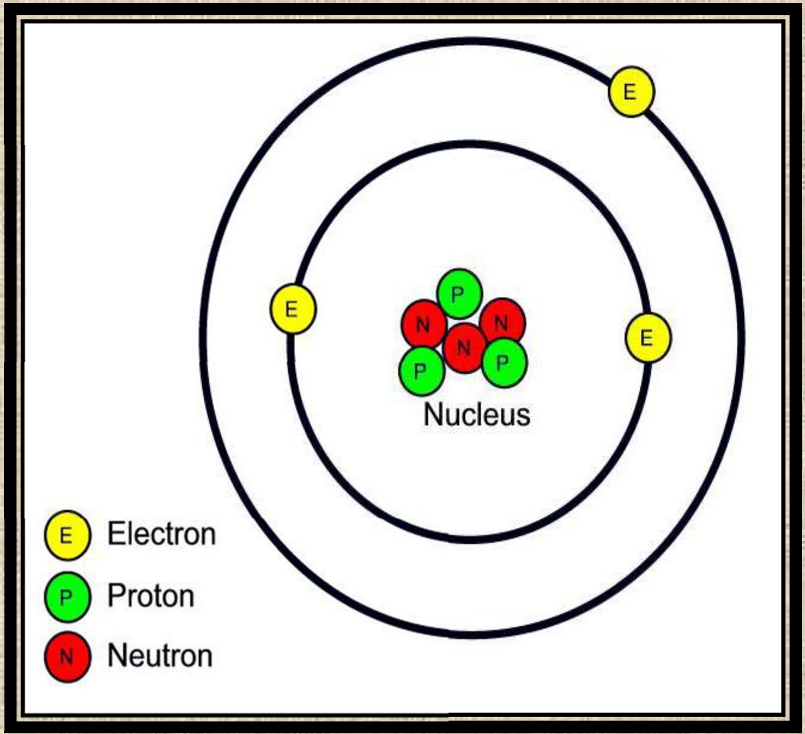
Characteristics of Neutron

Mass of Neutrons

- The mass of neutrons is equal to the mass of a proton. The relative mass of a neutrons is 1 u.

Charge of Neutrons

- Neutron has no charge. It is electrically neutral.



MODULE : 9

- **Numericals based on atomic number and mass number**

Atomic Number and Mass Number

Atomic Number

The atomic number of carbon is 6, so for carbon, Z=6.

...ons of an atom, ...nic number. It is

... the atoms of the same ... he numb... of proton... hence they ha... the sa...

No two elements can ... omic

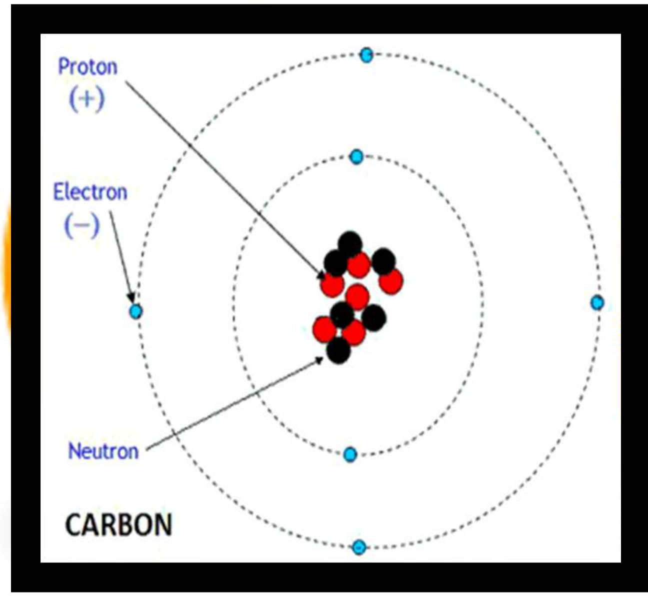
Atomic number tell us that it is carbon element.

No other element can have atomic number 6.

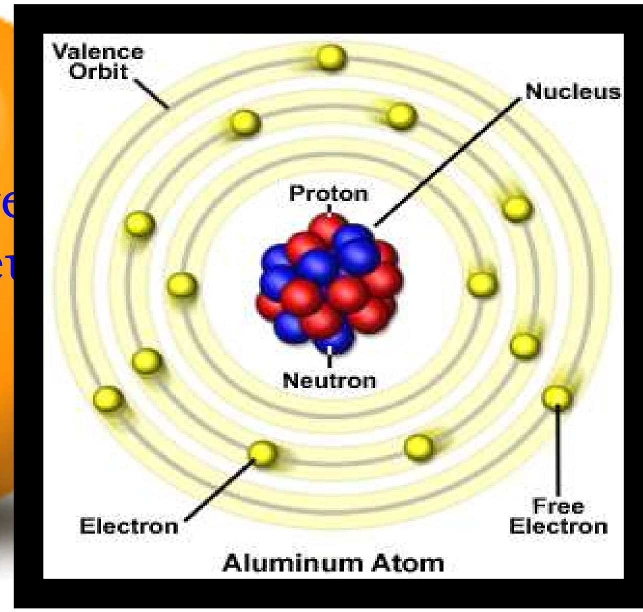
In a normal atom (or neutral atom), the number of protons is equal to the number of electrons in it.

So we can also say that the Atomic number of an element Is equal to the number of electrons in a neutral Atom.

Mass Number



hese are pre
n the nucle
n atoms.



and
lso
s.

For example, mass of carbons is 12 u because it has 6 protons and 6 neutrons, 6 u + 6u = 12u.

Similar, the mass of aluminium is 27u (13 protons + 14 neutrons).

Mass Number

The mass number of an element is denoted by the letter A

The mass number is defined as the sum of the total number of protons and neutrons present in the nucleus of an atom.

In the notation for an atom, the atomic number, mass number and symbol of the element are to be written as.

Mass number	Symbol of element
Atomic number	

$^{A}_{Z}X$

For example, nitrogen is written as $^{14}_{7}N$.

Relationship Between Mass Number and Atomic Number

Mass number = No. of protons + No. of neutrons

Since the number of protons in an atom is equal to the atomic number of the element.

We can rewrite the above relation by putting “Atomic number” in place of “No of Protons”

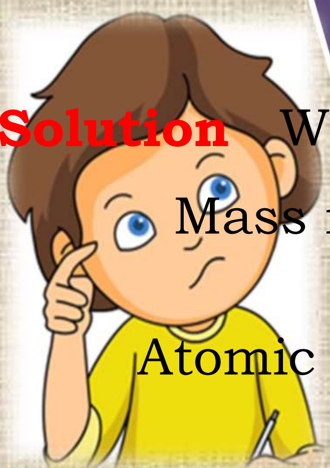
Mass number = Atomic number + No. of neutrons

MODULE : 10

- **Isotopes & different examples (Hydrogen)**

Sample problem 1.

Calculate the atomic number of an element whose atomic nucleus has Mass number 23 and neutron number 12. what is the symbol of the element?



Solution We know that:

$$\text{Mass number} = \text{Atomic number} + \text{No. of neutrons}$$

$$23 = \text{Atomic number} + 12$$

$$\text{Atomic number} = 23 - 12$$

$$\boxed{= 11}$$

The element having atomic number 11 is sodium and its symbol is Na. If, however, we indicate the atomic number and mass number also, then the symbol become $^{23}_{11}Na$, where 11 is the atomic number and 23 is the mass number.

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

Solution

We know that atomic mass is numerically equal to mass number of an atom. Since the helium atom has an atomic mass 4 u, therefore, the mass number of helium atom will be 4. and the number of proton in the helium nucleus has been given to be 2. Now,

Mass number = No. of protons + No. of neutrons

$$4 = 2 + \text{No. of neutrons}$$

$$\text{no. of neutrons} = 4 - 2$$

$$\boxed{= 2}$$

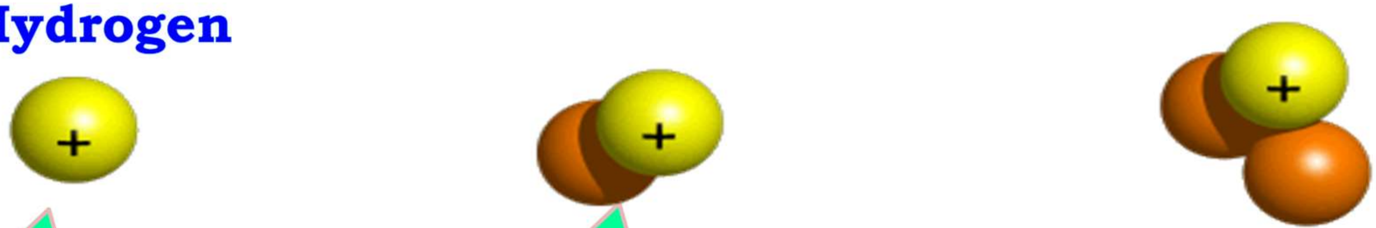
Thus, the helium atom has 2 neutrons.

MODULE : 11

- **Isotopes of Carbon, Oxygen & Neon**

ISOTOPES

Eg:- **Hydrogen**



Protium
Z=1
A=1

Deuterium
Z=1
A=2

Tritium
Z=1
A=3

ISOTOPES are the atoms of the same element having same Atomic number but different Atomic mass number.

Examples

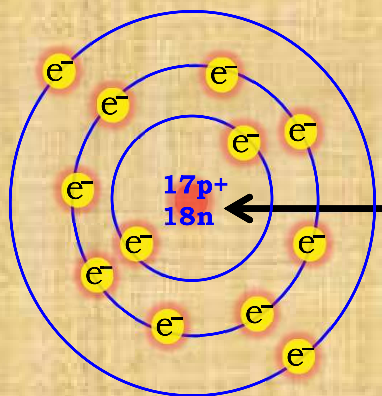
ELEMENT	MASS NUMBER (A)	ATOMIC NUMBER (Z)	NUMBER OF NEUTRON (N)
$^{12}_{6}C$	12	6	6
$^{14}_{6}C$	14	6	8

ELEMENT	MASS NUMBER (A)	ATOMIC NUMBER (Z)	NUMBER OF NEUTRON (N)
$^{35}_{17}Cl$	35	17	18
$^{37}_{17}Cl$	37	17	20

Number of neutrons in isotopes is different

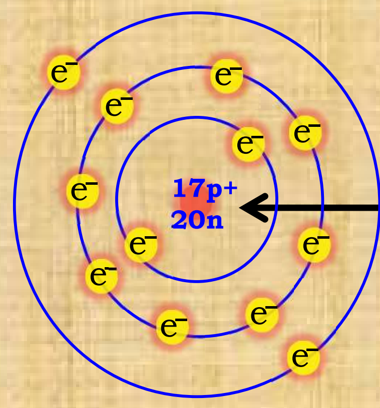
Chemical properties of isotopes are the same.

The diagrams of the two isotopes of chlorine are given below:



Nucleus contains 17 protons and 18 neutrons

(i) Cl – 35 isotope
Mass number or Atomic mass = 35



Nucleus contains 17 protons and 20 neutrons

(ii) Cl – 37 isotope
Mass number or Atomic mass = 37

Mass number of an atom is equal to its atomic mass

Isotopes of Hydrogen.

${}^{1}_{1}H$, ${}^{2}_{1}H$, and ${}^{3}_{1}H$,

The hydrogen element has
three isotopes havi
same ator
but differ
of 1,2

It is cl
t
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e table
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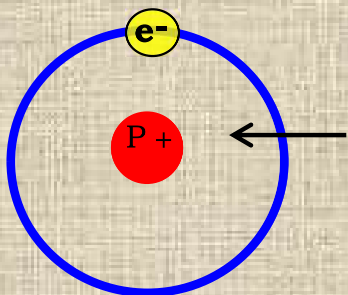
they
utrons
vely.

So isotopes exist
due to difference
in the number
of neutrons.

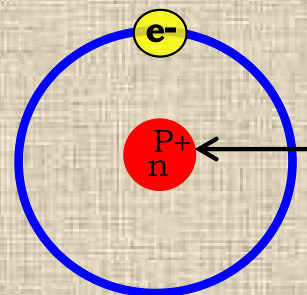
Name	Isotope	Protons		
Protium	${}^{1}_{1}H$	1		1
Deuterium	${}^{2}_{1}H$	1	1	1
Tritium	${}^{3}_{1}H$	1	2	1

The diagrams of the three isotopes of hydrogen are given below:



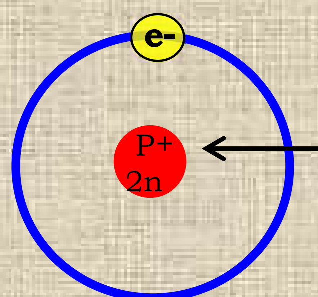
Nucleus
contain
1 proton
only

Ordinary hydrogen (or Protium)
Atomic mass = 1 u



Nucleus
contain
1 proton and
1 neutron

Heavy hydrogen (or Deuterium)
Atomic mass = 2 u



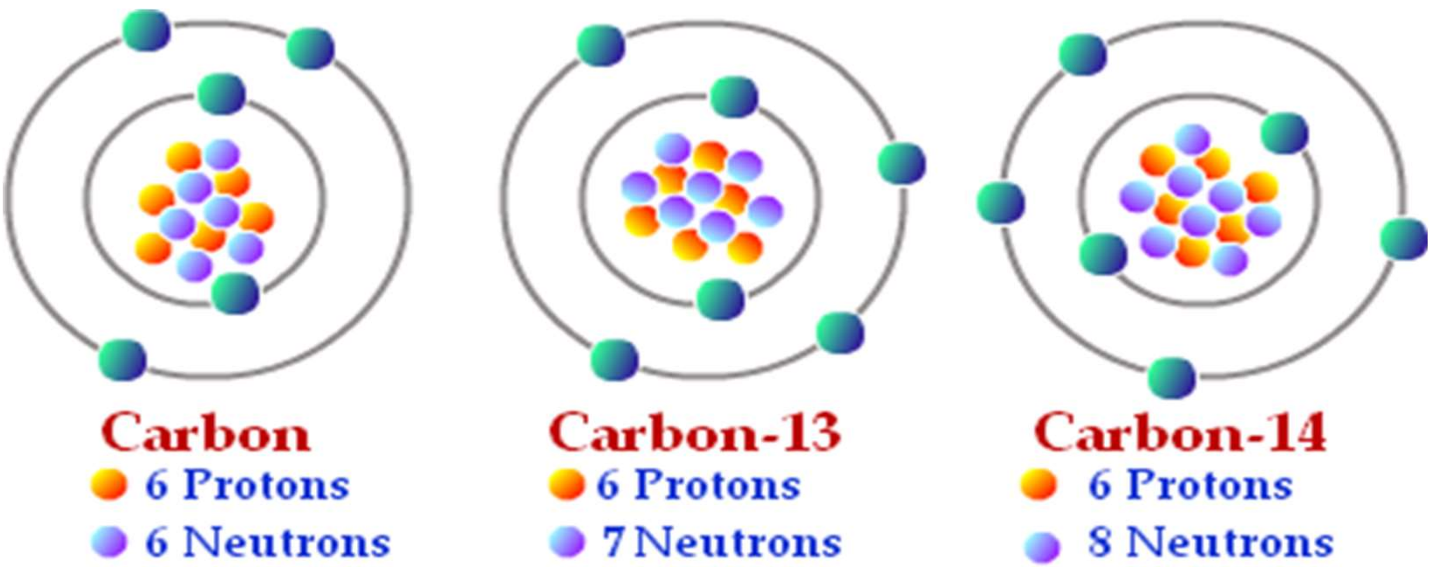
Nucleus
contain
1 proton and
2 neutron

Very heavy hydrogen (or Tritium)
Atomic mass = 3 u

MODULE : 12

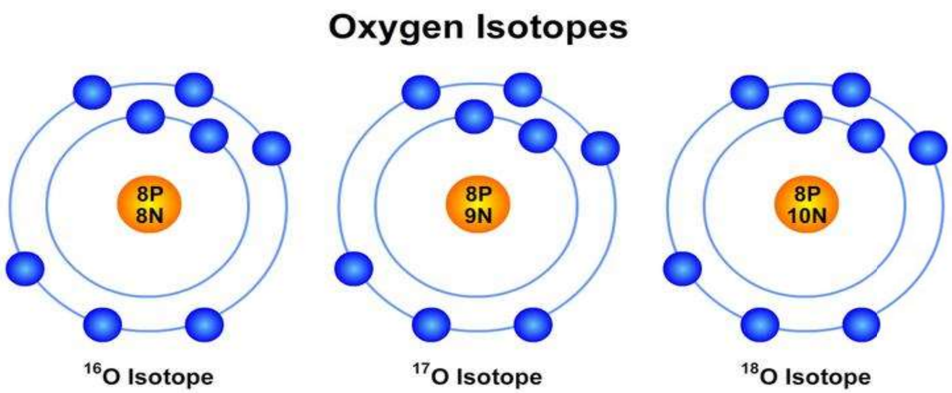
- **Isotopes & their application**

The carbon element has three isotopes having the same atomic number of 6 but different mass numbers of 12,13 and 14. the three isotopes of carbon can be written as



${}^{12}_{\boxed{6}}C$ ${}^{13}_{\boxed{6}}C$ ${}^{14}_{\boxed{6}}C$

All the isotopes of oxygen have the same atomic number of 8 but they have different mass numbers (or atomic masses) of 16,17 and 18 respectively.



$^{16}_{\boxed{8}}O$ $^{17}_{\boxed{8}}O$ $^{18}_{\boxed{8}}O$

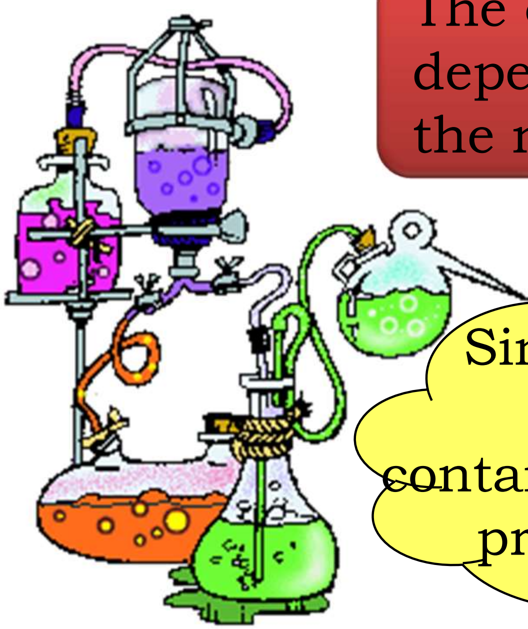
The various isotopes of an element can have slightly different physical properties such as densities, melting points and boiling points.

Since the masses of the isotopes of an element are slightly different, therefore, the physical properties of the isotopes of an element are slightly different.

It is obvious from the above symbols that all the isotopes of neon have the same atomic number of 10 but they have different mass numbers (or atomic masses) of 20,21 and 22 respectively.

Isotopes of Neon $^{20}_{\boxed{10}}Ne$ $^{21}_{\boxed{10}}Ne$ $^{22}_{\boxed{10}}Ne$

The chemical properties of an atom of the element depend on the number of proton and electrons, not on the number of neutrons.



Since all the isotopes of an elements contain the same number of proton and electrons.

The chemical properties of all the isotopes of an element are identical (or same).

MODULE : 13

- **Isobars**

1. The chlorine isotope $^{35}_{17}Cl$ has a mass of 35 u and its abundance (or proportion) in nature is 75%

2. The chlorine isotope $^{37}_{17}Cl$ has a mass of 37 u and its abundance (or proportion) in natural is 25%

The average atomic mass of chlorine atom. On the basic of above data.

Solution

$$[(35 \times \frac{75}{100} + 37 \times \frac{25}{100}$$

$$= (\frac{105}{4} + \frac{37}{4} = \frac{142}{4} = 35.5u]$$

This does not mean that any one atom of chlorine has a fractional mass of 35.5 u.

It mean that if you take a certain amount of chlorine, it will contain both isotopes of chlorine and the average mass is 35.5 u.

Bromine occurs in nature mainly in the form of 2 isotopes $^{79}_{35}Br$ and $^{81}_{35}Br$. If the abundance of $^{79}_{35}Br$ isotope is 49.7% and that of $^{81}_{35}Br$ isotope is 50.3%, calculate the average atomic mass of bromine.

Solution

We know that upper digit in the symbol of an isotope represents its mass (which is the same as its mass number). Now:

i) The mass of $^{79}_{35}Br$ isotope is 79 u and its abundance is 49.7%

ii) The mass of $^{81}_{35}Br$ isotope is 81 u and its abundance is 50.3%

$$= 79 \times \frac{49.7}{100} + 81 \times \frac{50.3}{100}$$

$$= \frac{3926}{100} + \frac{4074.3}{100}$$

$$= 3926.3 + 40.743$$

$$= 80.006 \qquad = 80\text{u}$$

Thus the average atomic mass of bromine is 80 u.

Applications of Radioactive Isotopes

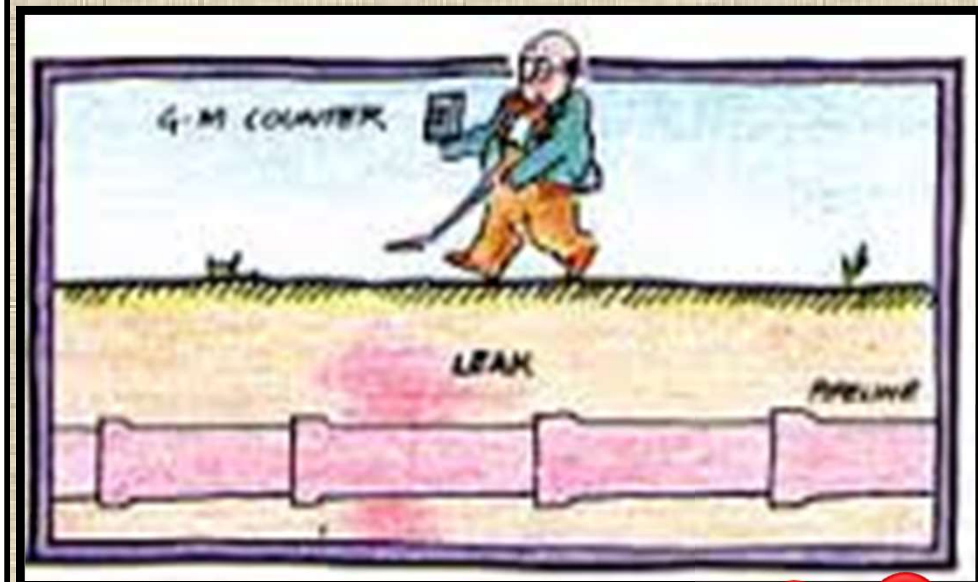
Uranium-235 (^{235}U) is used for nuclear fission and Production of energy.

Isotopes of some elements are used in the medical treatment of deadly disease like cancer.

Applications of Radioactive Isotopes

Iodine (^{131}I) is used in the treatment of **GOITRE** a disease of thyroid gland

Applications of Radioactive Isotopes



Radioactive isotopes are used in industry to detect the Leakage in underground oil Pipelines, gas pipelines and water pipe

14

ISOBARS

Let us consider two elements

Atoms of different elements having different atomic number but same atomic mass number

Examples

Isobar	Protons	Neutrons	Mass number
Argon (Ar)	18	22	40
Calcium (Ca)	20	20	40

Which two of the following atomic species are isotopes of each other and which two are isobars??

${}^{231}_{90}Z$, ${}^{230}_{91}Z$, ${}^{230}_{88}Z$, ${}^{233}_{90}Z$

Solution

(a) The isotopes of an element have the same atomic number but different mass numbers. The lower figure in the above given symbols indicate the atomic numbers. Now, in this case there are two atoms having the same atomic number of 90. so, the two isotopes will be:

$$^{231}_{90}Z, \text{and} \ ^{233}_{90}Z$$

(b) The isobars have different atomic numbers but same mass numbers. The upper figures in the given symbols indicate the mass numbers. In this case there are two mass number of 230. So, the two isobars will be:

$$^{230}_{91}Z, \text{and} \ ^{230}_{88}Z$$