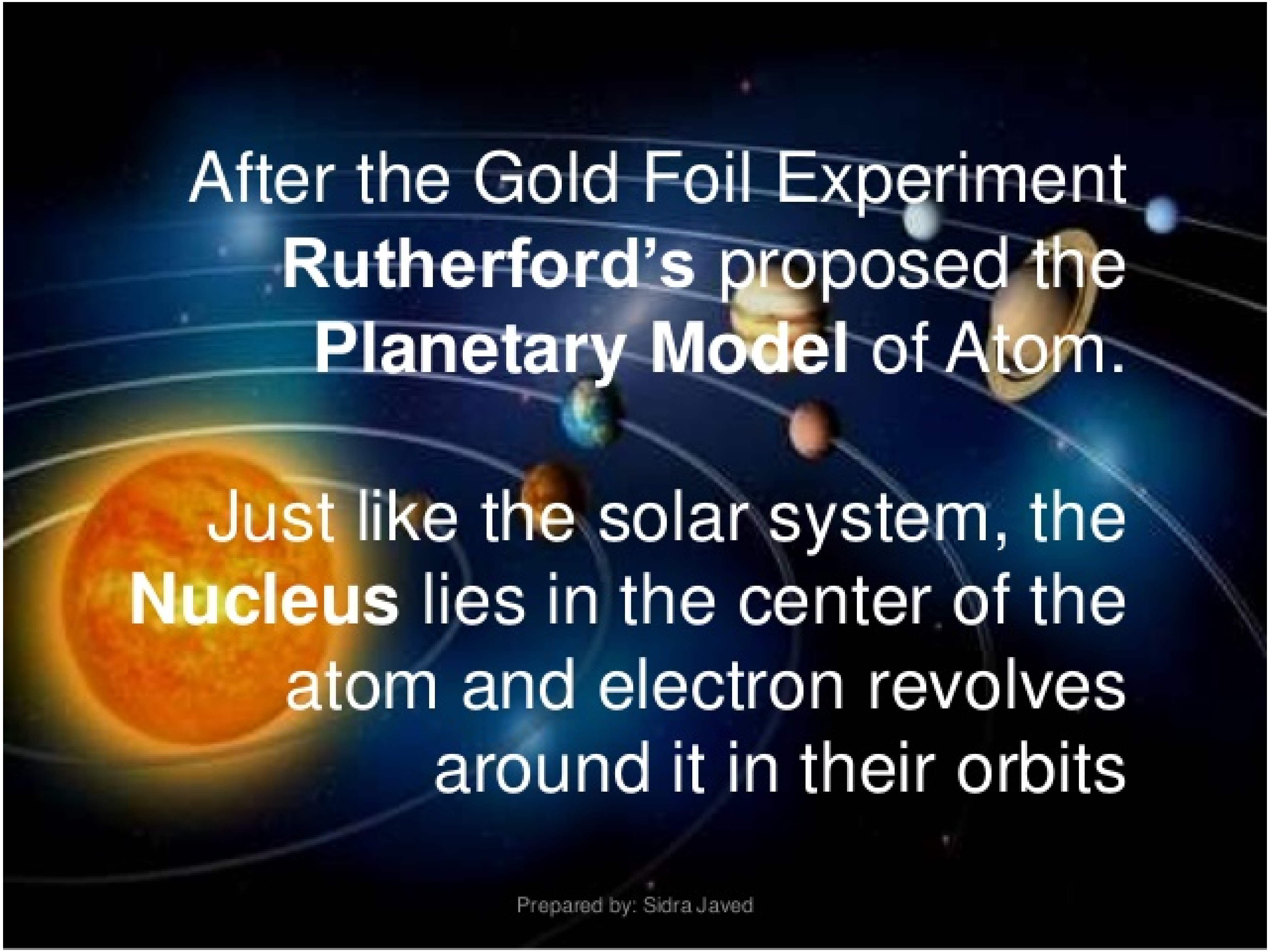
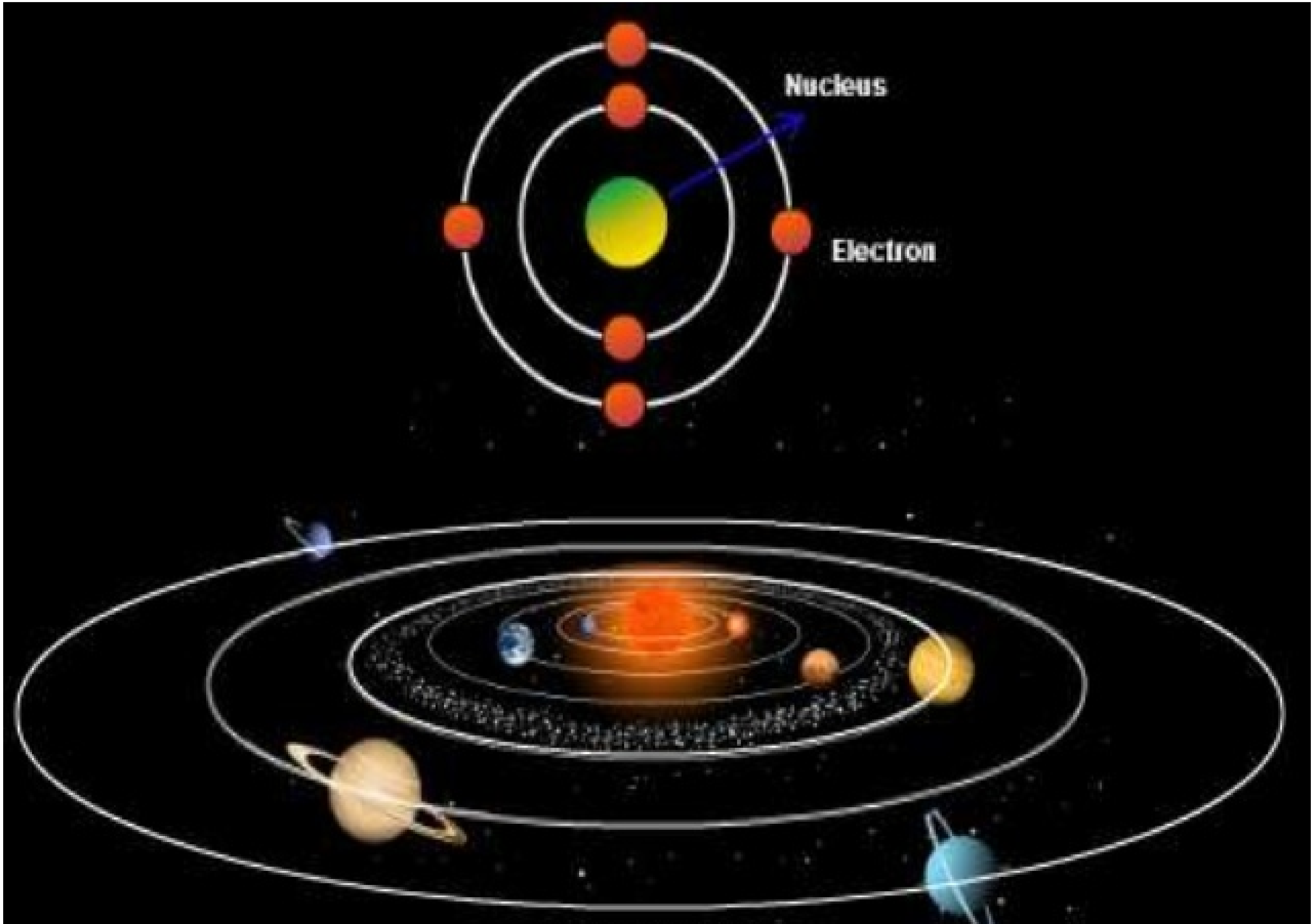

After the Gold Foil Experiment
Rutherford's proposed the
Planetary Model of Atom.
Just like the solar system, the
Nucleus lies in the center of the
atom and electron revolves
around it in their orbits
Prepared by: Sidra Javed



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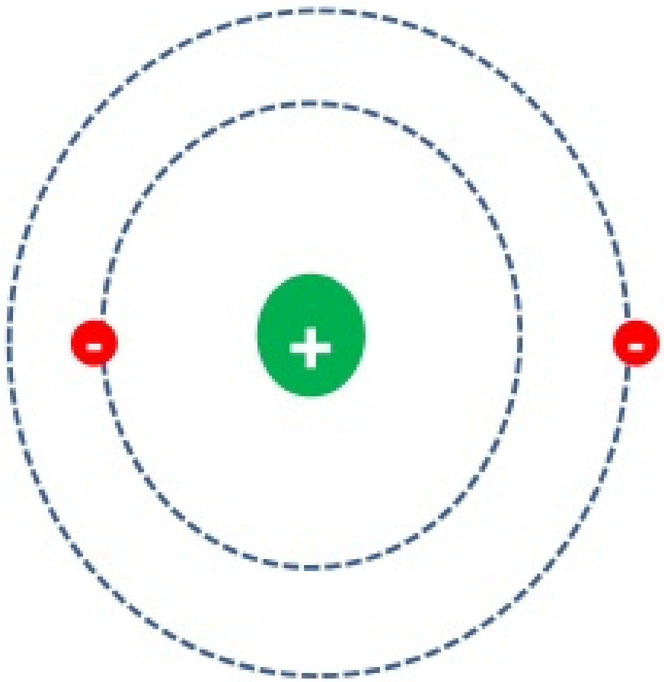
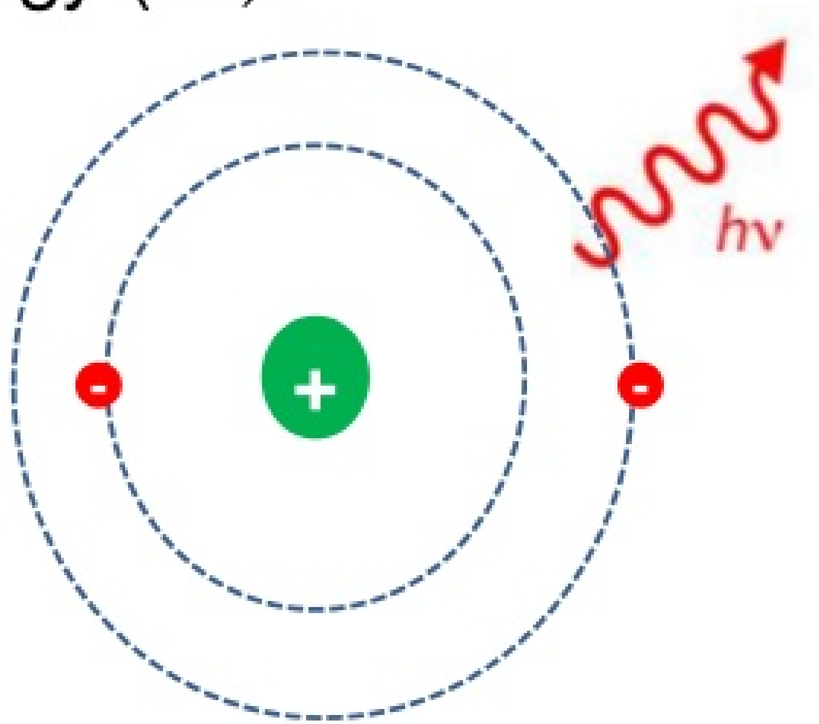
But!!

The Revolution of the electron in a circular orbit is not expected to be stable.



Any particle in a circular orbit would undergo acceleration.

During acceleration, charged particles would radiate energy (hν).

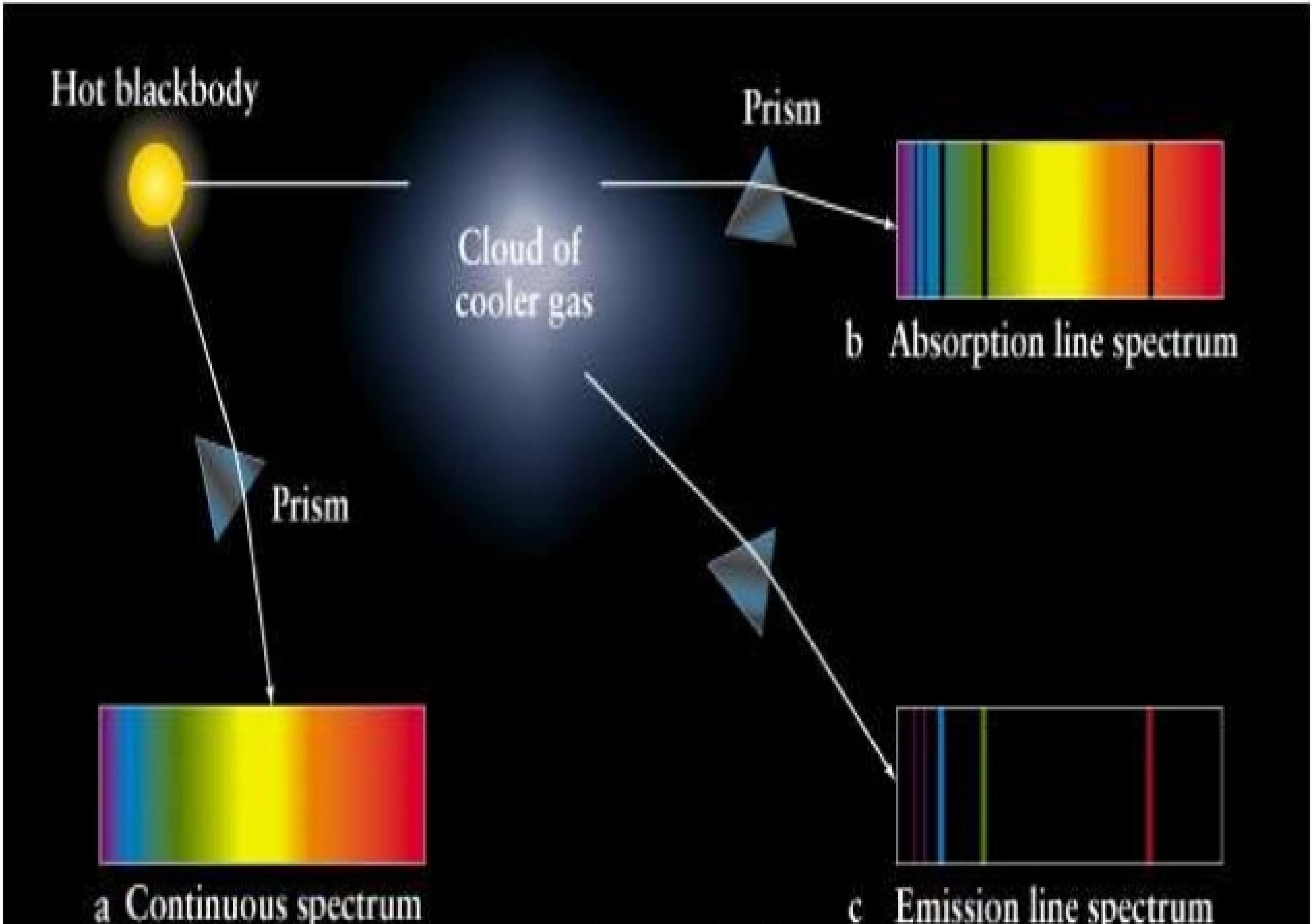


Thus, the revolving electron would lose energy and finally fall into the nucleus.

If this were so, the atom should be highly unstable and hence matter would not exist in the form that we know.

As the electron spiral inwards, their angular velocities and frequency would change continuously and so will the frequency of the energy emitted.

Thus, they would emit a continuous spectrum, in contrast to the line spectrum actually observed

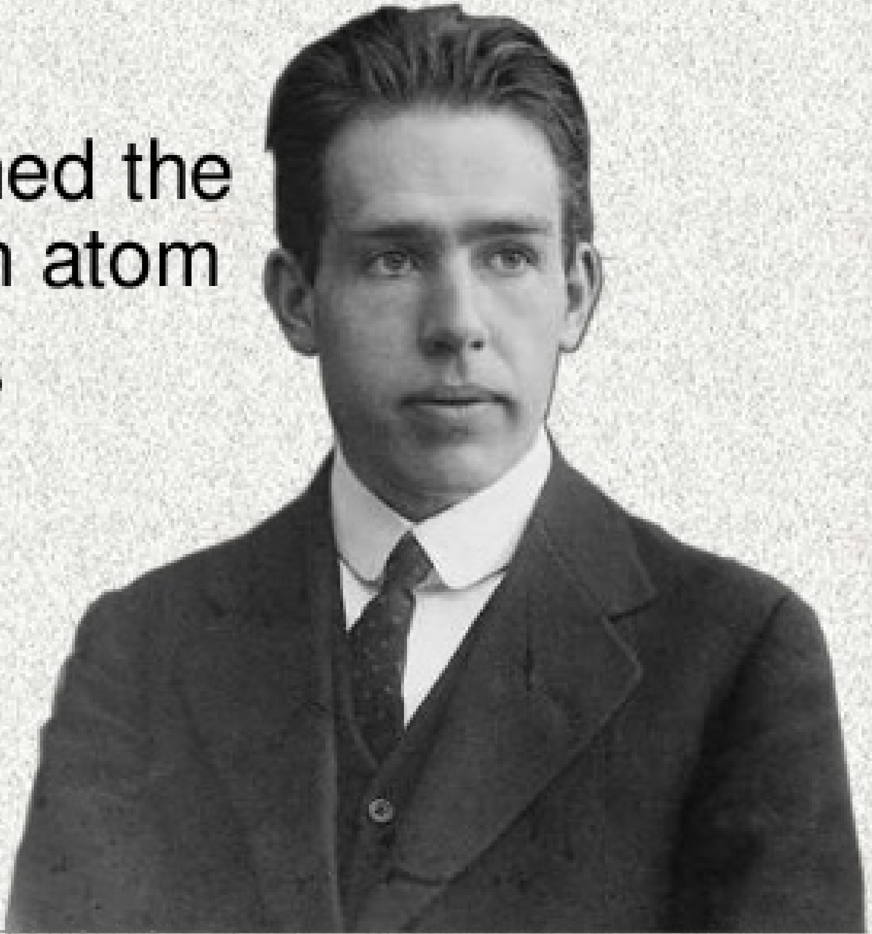


Hot blackbody
Cloud of cooler gas
Prism
b Absorption line spectrum
Prism
a Continuous spectrum
c Emission line spectrum

Neil Bohr, a Danish Physicist studied in Rutherford Laboratory since 1912.

He successfully explained the spectrum of hydrogen atom and presented Bohr's Atomic model.

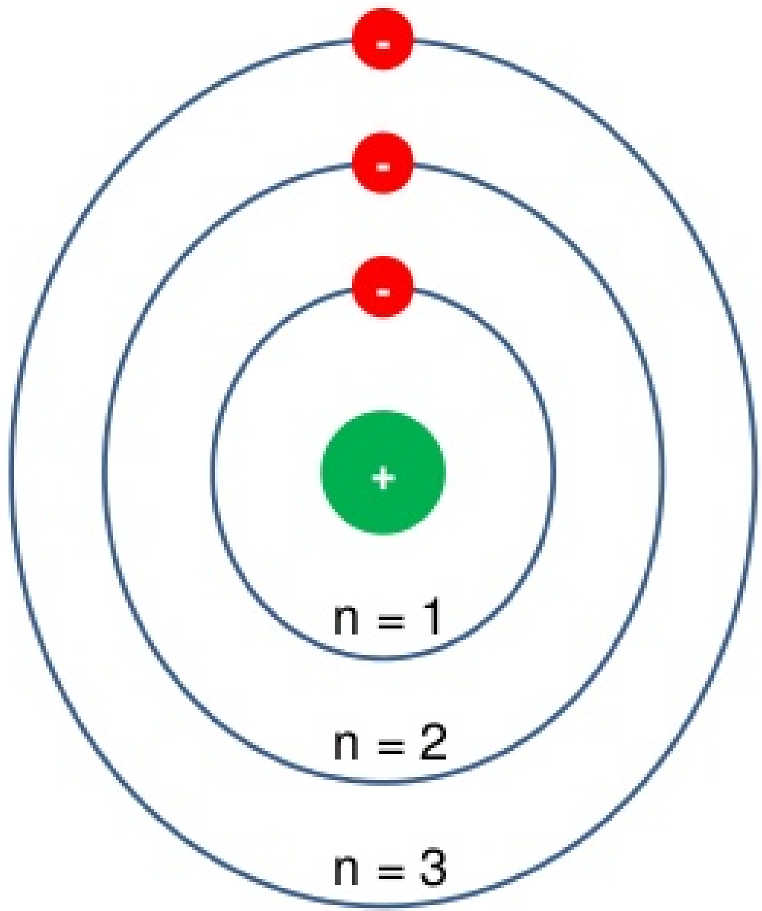
He was awarded Nobel Prize in 1922



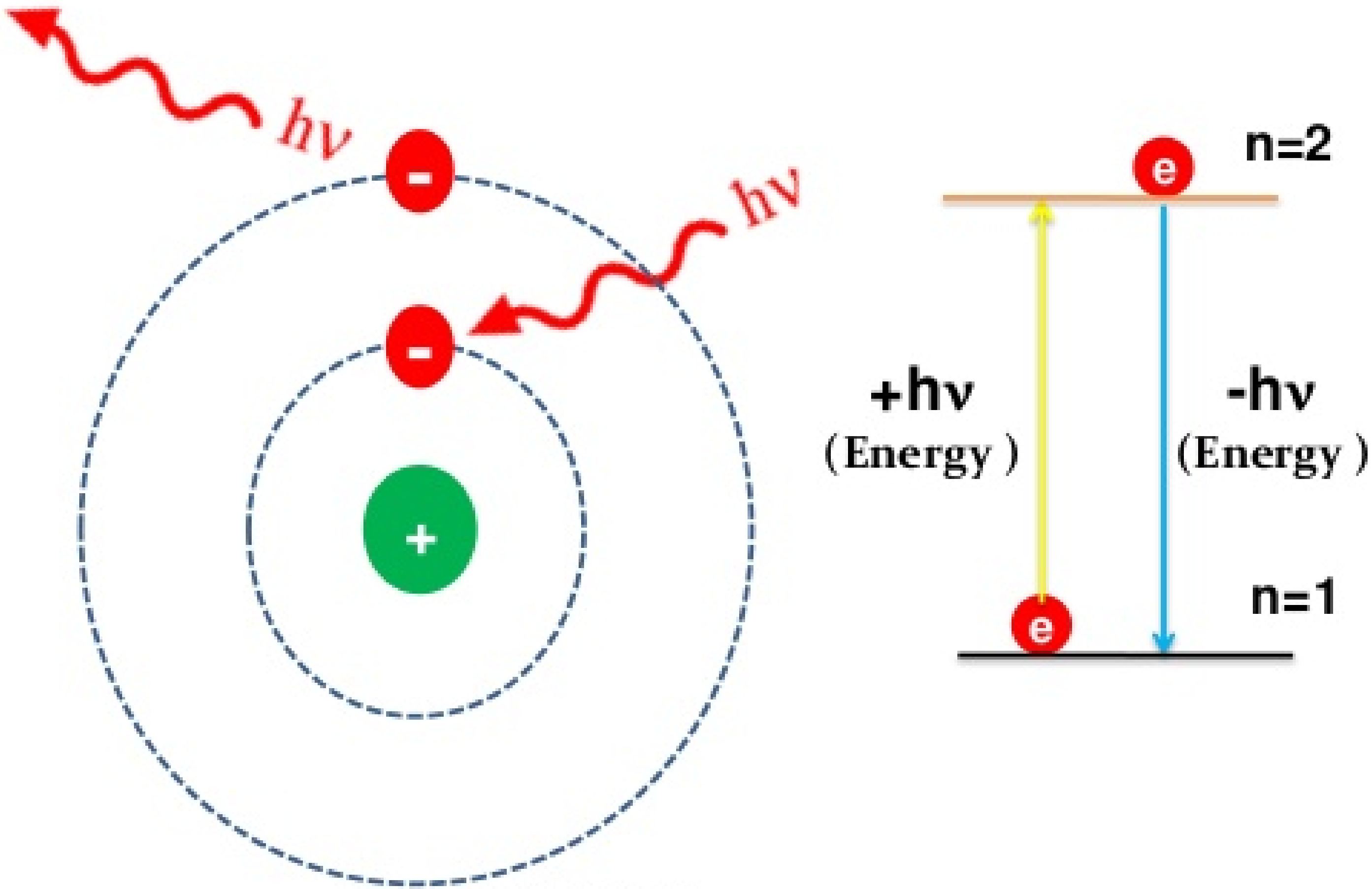
Bohr's Model of Atom

1- Electrons revolves around the nucleus in definite energy levels called orbits or shells in an atom without radiating energy.

2- As long as an electron remain in a shell it never gains or losses energy.



3- The gain or loss of energy occurs within orbits only due to jumping of electrons from one energy level to another energy level.



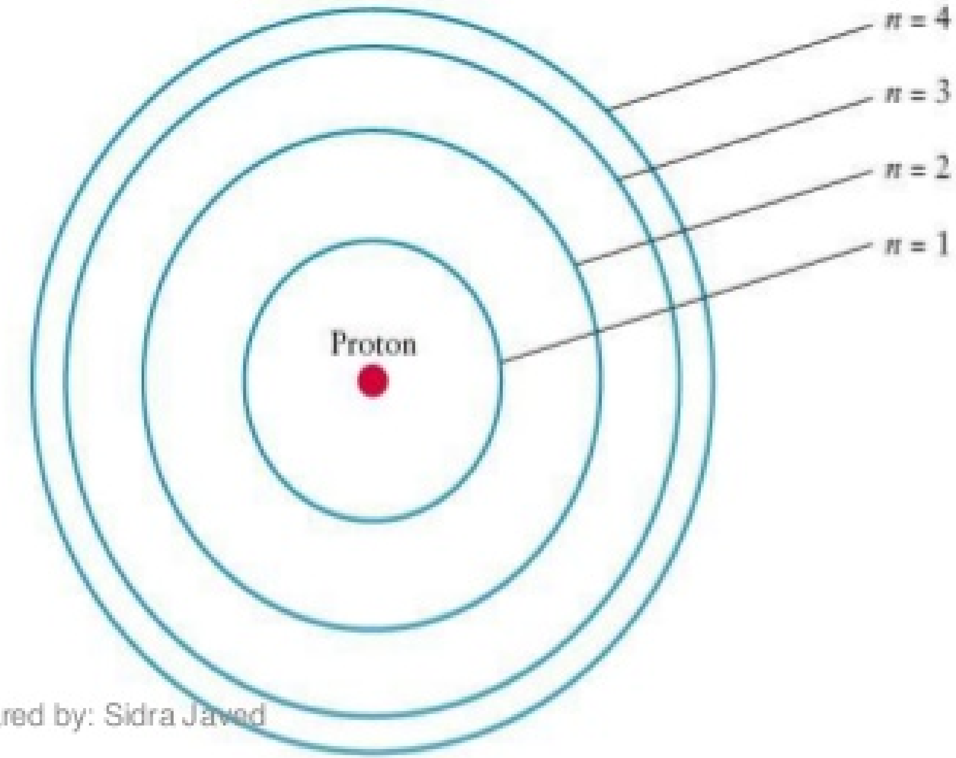
4- The angular momentum (mvr) of an electron is equal to nh/2π.

The angular momentum of an orbit depends upon its quantum number (n) and it is integral multiple of the factor h/2π

i.e. $mvr = nh/2\pi$

Where,

n = 1, 2, 3, 4,….



Applications Of Bohr's Atomic Model

- Derivation of Radius of an Orbit of an atom

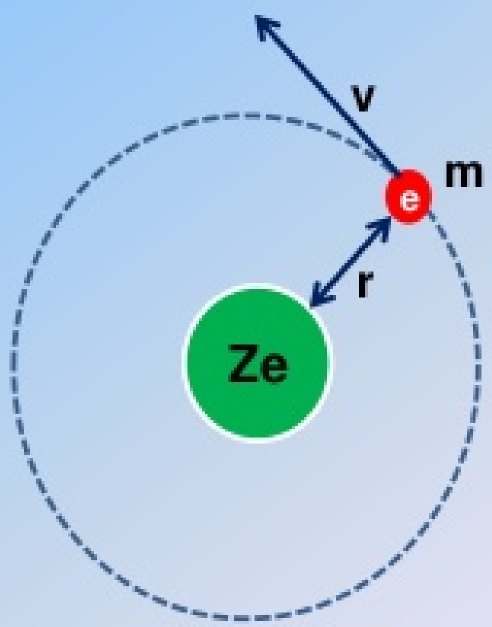
- Derivation of Energy of an Orbit

- Derivation of Wave Number ($\bar{u}$)

Derivation of Radius of an Orbit of an Atom

Consider an atom having an electron e^- moving around the nucleus having charge Ze where Z is the atomic number.

Let m be the mass, r the radius of the orbit and v, the velocity of the revolving electron.



According to Coloumb's law, the electrostatic force of attraction b/w nucleus and electron :

$$F_c = \frac{q_1 q_2}{4\pi\varepsilon_o r^2} = \frac{Ze.e}{4\pi\varepsilon_o r^2}$$

$$= \frac{Ze^2}{4\pi\varepsilon_o r^2}$$

Where ε_o is the vacuum permittivity constant (ε_o= 8.84 x 10^{-12} C^2/J.m)

Centrifugal force acting on the electron = $\frac{mv^2}{r}$

The two forces are equal and balance each other

$$\frac{mv^2}{r} = \frac{Ze^2}{4\pi\varepsilon_o r^2}$$

$$mv^2 = \frac{Ze^2}{4\pi\varepsilon_o r} \ldots\ldots\ldots\ldots (1)$$

$$r = \frac{Ze^2}{4\pi\varepsilon_o mv^2} \ldots\ldots\ldots\ldots (2)$$

According to Bohr's postulate:

$$mvr = \frac{nh}{2\pi} \ldots\ldots\ldots\ldots\ldots(3)$$

$$v = \frac{nh}{2\pi mr}$$

$$v^2 = \frac{n^2h^2}{4\pi^2m^2r^2} \ldots\ldots\ldots(4)$$

Put value in eq(2).

$$r = \frac{Ze^2}{4\pi\varepsilon_\circ m} \times \frac{4\pi^2 m^2 r^2}{n^2 h^2}$$

$$\frac{1}{1} = \frac{Ze^2 \pi m r}{\varepsilon_\circ n^2 h^2}$$

$$Ze^2 \pi m r = \varepsilon_\circ n^2 h^2$$

$$r = \frac{\varepsilon_\circ n^2 h^2}{Ze^2 \pi m} \ldots\ldots\ldots\ldots\ldots(5)$$

For Hydrogen atom, Z = 1

$$r = \frac{\varepsilon_\circ n^2 h^2}{Ze^2 \pi m}$$

$$r = \frac{\varepsilon_\circ n^2 h^2}{(1)e^2 \pi m}$$

$$r = \frac{\varepsilon_\circ n^2 h^2}{\pi m e^2} \ldots\ldots\ldots\ldots(6)$$

$$r = n^2 a^o$$

Where a^o is a constant quantity,

$$a^o = \frac{\varepsilon_\circ h^2}{e^2 \pi m}$$

$$a^o = 0.529 x 10^{-10} m$$

$$a^o = 0.529 \overset{o}{\mathrm{A}}$$

$$r = n^2 . a^o$$

So, $r = n^2 \times 0.529 \overset{o}{A}$

Therefore radius of orbits having n = 1, 2, 3… are as follows:

When n=1: $r_1 = (1)^2 \times 0.529 = 0.529 \overset{o}{A}$

When n=2: $r_2 = (2)^2 \times 0.529 = 2.11 \overset{o}{A}$

When n=3: $r_3 = (3)^2 \times 0.529 = 4.75 \overset{o}{A}$

When n=4: $r_4 = (4)^2 \times 0.529 = 8.4 \overset{o}{A}$