CHAPTER 1

THE DEVELOPMENT OF ATOMIC PHYSICS

A. Introduction

Initially the theory of matterial structure was not based on the experiment result. Scientist studied the relation among some physics phenomenon about electricity and mangetism related with atomic structure. In Table 1.1 shown the development of atomic phisics.

Table 1.1 The Development of Atomic Phisics

Year	Scientist	Development
Yunani Era	Democritus	Atom is the part of matter that it can not be devided again.
1704	Isaac Newton	Propose the mechanical universe
1803	John Dalton	Propose the atomic theory that atom is a masive particle,
1832	Michael Faraday	Develop the electolysis law.
1859	J Plucker	Produce the tube of cathode ray.
1869	Dmitri Mendeleev	Develop the periodic table of elements.
1873	James Clerk Maxwell	Study the relation between electical field and magnetic field.
1874	G.J. Stoney	The electricity consist of discret negative particle that called electron.
1879	Sir William Crookes	Study the cathode ray (electron)
1886	E. Goldstein	Study the canal rays
1895	Wilhelm Roengent	Study the x ray using the tube of cathode ray,
1896	Henry Becquerel	Study the effect of x ray in photograph film.
1897	J.J. Thomson	Using the cathode ray tube to determine the ratio of (e/m) of electron = $1,759.10^8$ coulomb/gram.
1898	Rutherford	Study the radiation that radiated by uranium and thorium (alpha and beta radiation).
1898	Marie Sklodowska Curie	Study the radioactivity of uranium and thorium. With her husband Pierre Curie Study the radioactivity of polonium and radium.
1900	Soddy	Study the half life of the radioactive element
1900	Max Planck	Using quanta for a unit of a discrete energy.
1903	Nagaoka	Postulate model atom a "Saturnian" atomic model.
1904	Abegg	Study the inert gas have stable electron configuration.

1905	Albert Einstein	Publishe the famous equation $E = mc^2$.
1906	Hans Geiger	Develope the electrical devices that can detect the alpha particle.
1909	R.A. Millikan	Conduct the oil drop experiment to determine the electron charge e = $1,602.10^{-19}$ C and the electron mass m = $9,11.10^{-31}$ kg.
1911	Rutherford	Conduct the experiment of alpha scattering in plate of gold.
1914	H.G.J. Moseley	Rearange the periodic table based on atomic number.
1919	Aston	Found the excistence of isotope using the mass spektrograf apparatus.
1922	Niels Bohr	Propose the Bohr atomic model
1923	de-Boglie	Found the dualism behaviour of electron as a wave and particle.
1927	Heisenberg	Propose the uncertainty principle.
1929	Cockroft/Walton	Built the first linear accelerator.
1930	Schrodinger	Found the Schodinger equation.
1930	Paul Dirac	Propose the antiparticle.
1932	James Chadwick	Found the neutral particle of netron.
1938	Lise Meitner, Hans, Strassman	Found the fission reaction.
1941-1951	Glenn Seaborg	Syntesize 6 transuranium elements.
1942	Enrico Fermi	Found the first controlled chain reaction.

B. The Atomic Theory of Democritus

Demokritus (460-370 SM) formulates an idea that matter can be divided in the smaller part until the part of matter can not be divided again. The part of matter that can not be divided again is called atom. Atomos means can not be divided again. This atomic theory was based on the idea and was not based on the result of the experiment. This atomic concept was develope by his student Leukipos. Leukipos concluded that the universe concist of atoms.

C. Teori Atom Dalton

In 1802 John Dalton have conducted experiment reaied with the development of atom. The fundamental atomic theory of Dalton: Atom merupakan partikel terkecil yang tidak dapat dibagi lagi.
1. Atom of element can not change to be the atom of others element.
2. Two atoms or more that from the different elements can combine to form a molecule (water: (H_2O). .
3. Atoms in molecule have a certain ratio the number of all mas is constant.

4. If two kind of atom combine and form 2 molecules or more, so the same atoms have a simple ratio. Example molecule CO and CO_2. Atom C in CO with atom C in CO_2 have a simple ratio.

Figure 1.1 John Dalton

In this era, the atomic theory develope. The result of experiment showed that atom still can be devided to be proton, netron, and electron. The nucleus of element can change to be a nucleous of other elements.

D. Thomson Atomic Model

Electron was found by Thomson in 1897. Electron has a negative charge. Atom has a neutral charge. It means in atom also has a positive charge particle. It is predicted that all mass of the atom is consentred in a positif charge particle.
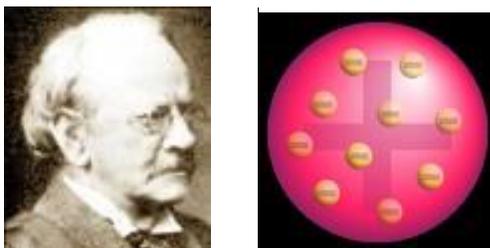

Figure 1.2. Thomson and his Atomic Model

Thomson propose an atomic model that different from the Dalton atomic model. Acording the Thomson atomic model, the positive charge particle are spread in all part of the atom homogeniusly. The positive charge is netralized by electrons. The Thomson atomic model is called plum-puding model.

Geiger and Marsden in 1911 based on the suggestion from Rutherford, they conducted exmeriment using alpha ray. The experiment is conducted by bombarding a thin layer of gold using alpha particle. The scterring of alpha particle is observer in the zink-sulfide screen.

If the Thomson atomic model is true, all of alpha ray will pass through the thin layer of gold. The fact, most of the alpha particle pass trough the thin layer of gold and some of the alpha particle will be scaterred and reflected in the angle of 90° until 180°. This phenomenon is nor relevan with the Thomson atomic model.
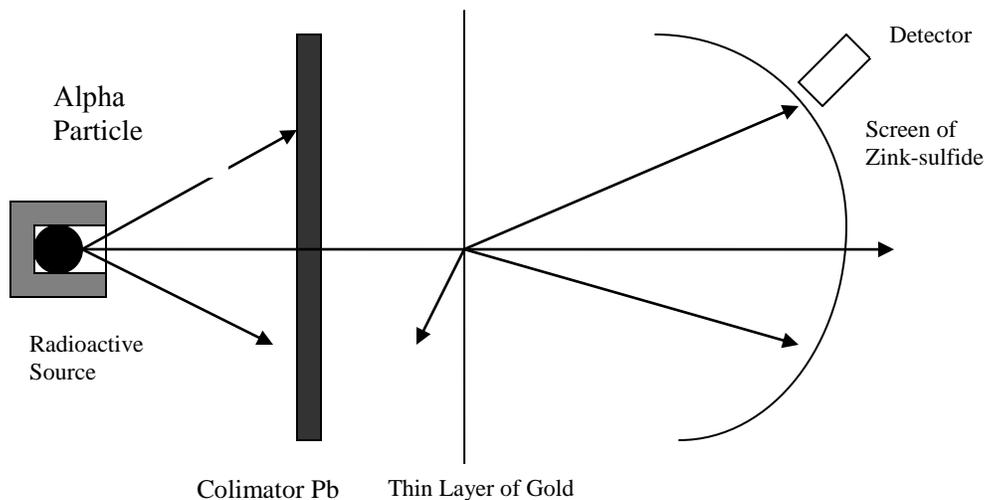
Figure 1.3. Experiment of Rutherford Scattering

Based on the experiment, it can be concluded that the positive charge particle did not spread in all part of atom, but it concentrated in the center of atom to repel the apha particle.

Because of the alpha particle has a large mass (7000 times the electron mass) and has a large speed (2.10^7 m/s), it clear that a strong force acts in alpha particle. As a result the alpha particle will deflect with a big angle.

E. The Rutherford Atomic Model

Rutherford stated that the positive charge particle and most atomic mass is consentrated in the center of atom that it called a nucleous. Electron move in rotational path with the nucleous as a center. This motion is similiar with the motion of planets with the sun as a center.
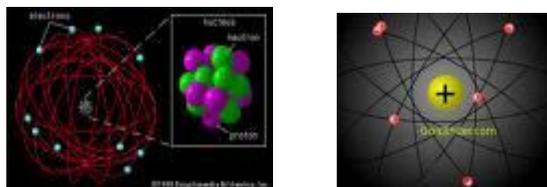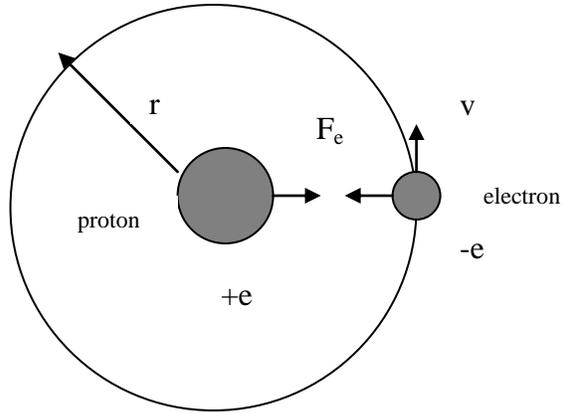

Figure 1.4. The Rutherford Atomic Model

Gambar 1.5. The Force Equilibrium in Hidrogen Atom

The force that exert in hydrogen atom are:

- Centripetal Force : $F_s = \dfrac{mv^2}{r}$, where m is electron mass, v speed of electron, and r is orbit radius of electron.

- Electrostatical force : $F_e = \dfrac{1}{4\pi\varepsilon_o}\dfrac{e^2}{r^2}$, where e elementary charge of elektron.

The orbit of the elektron will be stable if:

$$F_s = F_e$$

$$\frac{mv^2}{r} = \frac{1}{4\pi\varepsilon_o}\frac{e^2}{r^2}$$

$$v^2 = \frac{1}{4\pi\varepsilon_o}\frac{e^2}{r^2}\frac{r}{m}$$

$$\Leftrightarrow v = \frac{e}{\sqrt{4\pi\varepsilon_o mr}} \quad \text{...} \quad (1.1)$$

Energy of hydrogen atom

The energy of hydrogen (E) atom consist of kinetic energy (K) and potential energy (V):

$$E = K + V$$

$$E = \frac{1}{2}mv^2 - \frac{e^2}{4\pi\varepsilon_o r}$$

$$E = \frac{1}{2}m\left(\frac{e}{\sqrt{4\pi\varepsilon_o mr}}\right)^2 - \frac{e^2}{4\pi\varepsilon_o r}$$

$$E = \frac{1}{2}m\frac{e^2}{4\pi\varepsilon_o mr} - \frac{e^2}{4\pi\varepsilon_o r}$$

$$E = \frac{e^2}{8\pi\varepsilon_o r} - \frac{e^2}{4\pi\varepsilon_o r}$$

$$\Leftrightarrow E = -\frac{e^2}{8\pi\varepsilon_o r} \qquad \dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots \text{(1.2)}$$

Sign (−) states that force that exert in electron is in the direction of −r. The total energy in atom is negative, it means that the electrons were binded by nucleous. If the total energy of the atom is positve, it means that the electrons have not be bound by nucleous.

Based on equation (1.2), it seem the energy reduction of the electron can cause the reduction of the orbit radius of the electron. Finally the electron will be fallen in the nucleous. Acording the clasical mehanics, the motion of the electron in atom follow the spiral motion, because electron is accelerated, so the electron emit energy.

The elektromagnetic wave that is emited by electron is continu. It means that the atomic spectra is continu. The fact that the atomic spectra is discrete.
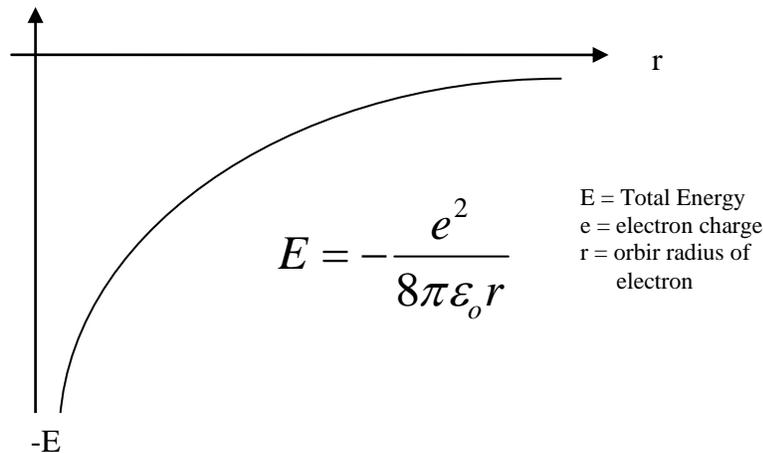

$$E = -\frac{e^2}{8\pi\varepsilon_o r}$$

E = Total Energy
e = electron charge
r = orbir radius of electron

Figure 1.6. The Relation Total Energy Atom With Radius

F. Problems

1. Explain the weakness the atomic theory of Demokritus, Dalton, dan Thomson!
2. Explain the part of the atomic theory of Demokritus, Dalton, dan Thomson that still relevan (true) until now!
3. What is the experiment that show the weakness of the Thomson model? What phenomenon which is showed by the exeperiment?
4. Determine 5 scientist that have proposed the atomec theory/model until now!
5. Hydrogen atom is the simplest atom that consist of one proton and and electron. If the distance between proton and electron is 0,529 angstrom, determine the atractive force between electron and proton.
6. To separate hydrogen atom to be one proton and one electron is required the energy 1,36 eV. Determine the orbit radius and speed of electron in hydrogen atom!
7. Acording the Rutherford atomic theory, Helium atom consist of 2 proton and 2 electron. If the distance nucleous and electron 0,529 angstrom, determine the Coulomb force which exert in each electron!
8. Proton with energy 1MeV is bombarded in the gold nucleous, determine the shortest distance that can reach by proton from the gold nucleous ! (Atomic number of gold/Aurum=79)
9. Explain the part of the Rutherford atomic theory that still relevan until now!
10. Explain the failure of the Rutherford atomic theory!

G. Reference

Yusman Wiyatmo. 2008. *Fisika Atom dalam Perspektif Klasik, Semiklasik, dan Kuantum*. Yogyakarta: Pustaka Pelajar