Discovery of isotopes

Dempster mass spectrometer

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Article

Discovery of isotopes and dempster mass spectrometer

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Abstract:

The present article aims to speak briefly about isotopes, discovery of it, the methods of measuring its different masses, dempster mass spectrometry, force of both electric and magnetic field and finally the charge mass ratio.

Introduction:

Isotopes are those elements having the same atomic number (number of protons) but different numbers of neutrons; so, they have different mass number values and that's why they have different physical properties but have the same chemical properties.

Isotopes word has a Greek root of **isos** which means equal, and **topos** which means place as the isotopes of any element have the same position in the periodic table.

Examples of isotopes:

These are some common elements having isotopes like Hydrogen, Carbon, Uranium, Chlorine.

- ✓ **Hydrogen isotopes:** The most common isotope of hydrogen is **protium (H)**, which has one proton and no neutrons and is the most common one. **Deuterium (D)**, another hydrogen isotope, contains one proton and one neutron, making it twice as heavy as protium. **Tritium (T)**, the third hydrogen isotope, consists of one proton and two neutrons.

- ✓ **Carbon isotopes:** The three most common isotopes of carbon are **carbon-12, carbon-13, and carbon-14**.

- ✓ **Uranium isotopes:** The three most common isotopes of uranium are **Uranium-234, Uranium-235, and Uranium-238** which is the most common one

- ✓ **Chlorine isotopes:** Chlorine has two stable isotopes; **Chlorine-35 and Chlorine-37**

Discovery of isotopes:

Frederick Soddy found that if an element immitted α-particle its atomic number decreases by 2 and its mass number decreases by 4, and if the element immitted β-particle its atomic number increases by 1 and its mass number remain the same.

So, if an element immitted two β-particle and one α-particle the element will be the same atomic number but different mass number and this was the first postulate about isotopes and due to that Frederick Soddy lately received Nobel Prize in Chemistry in 1921.

Experiments on isotopes:

In 1897 J.J. Thomson was using cathode ray tube to apply experiments on atoms and while studying neon he noticed that not all the atoms of neon behave like the other, and he said that it sounds like a mixture of two gases, but it was the fires evidence of isotopes existence.

In 1921 Aston developed his principle of mass spectrograph which depends on applying an electric field and a magnetic field in different directions on a cathode ray tube and receive the charged element on a detector after passing through the two fields

And due to the difference of masses of isotopes they have different scattering angels as scattering angel is inversely proportional to the mass.

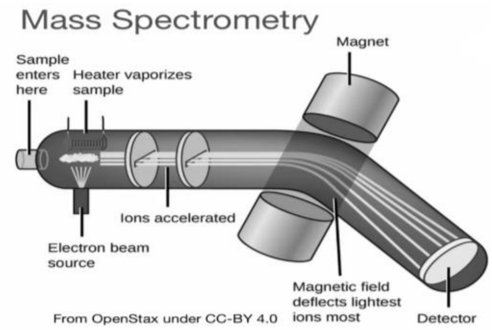
He could get graphs (on photographic plates) of some elements and received the Nobel Prize for that in the same year.

Dempster mass spectrometer:

Dempster made research over isotopes of Uranuem using mass spectrometer, this isotope has ability to cause a rapidly expanding fission nuclear chain reaction allowed the development of the atom bomb and nuclear power.

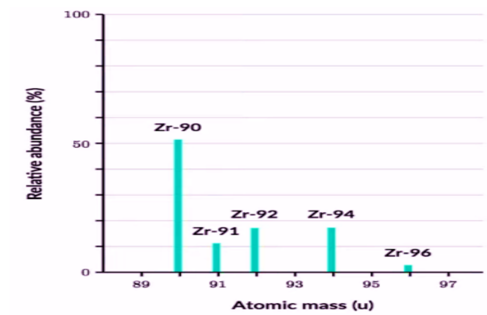
A spectrometer consists of a magnetic field generator, charged plates producing electric field, a sample of matter, heater to vaporize the sample and a photographic plate to receive the vaporized sample.

When the sample becomes a vapor due to the heater and carries charge on it due to the electron beam source it must be affected by both electric and magnetic field (*Freuse10.Pdf*, n.d.).



But if the vaporized element has isotopes, it will have different masses and due to that it will have different scattering angels produced by the same electric and magnetic field applied.

As scattering angel is inversely proportional to mass so, we will receive the molecules of the matter in different points on the detector and we can plot a relation between the percentage of the isotope and its atomic mass to get specifically the mass of the isotopes like the figure.



Charge mass ratio:

When the particle is accelerated by the electric field it will possess a kinetic energy which is equal to the work:

$$K.E = W = F\,L$$

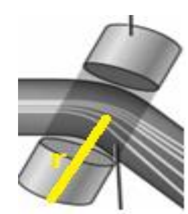
But we know that the electric field can be calculated by:

$$E = \frac{F}{q} = \frac{V}{L}$$

So; $$F\,L = q\,V$$

So that:

$$\frac{1}{2} M v^2 = q\,V \qquad (1)$$



When the moving particle is under the impact of magnetic field it will be moving in a curvy path, so the force applied on it will be centrifugal force in addition to the magnetic field force.

In equilibrium:

$$\frac{Mv^2}{r} = \mathrm{q}v\mathrm{B} \qquad i.e. \quad \frac{2}{r} \cdot \frac{1}{2} M v^2 = qvB \qquad (2)$$

From (1) and (2): $$v = \frac{2V}{rB} \qquad (3)$$

From (3) in (1): $$\frac{q}{M} = 2V/B^2 r^2$$

As Millikan could to calculate the value of the chare of the electron (e=1.602x10^{-19} Coulomb) and we know how to get the value of the charge mass ratio by the last equation, we can calculate the different masses of isotopes of any element.

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