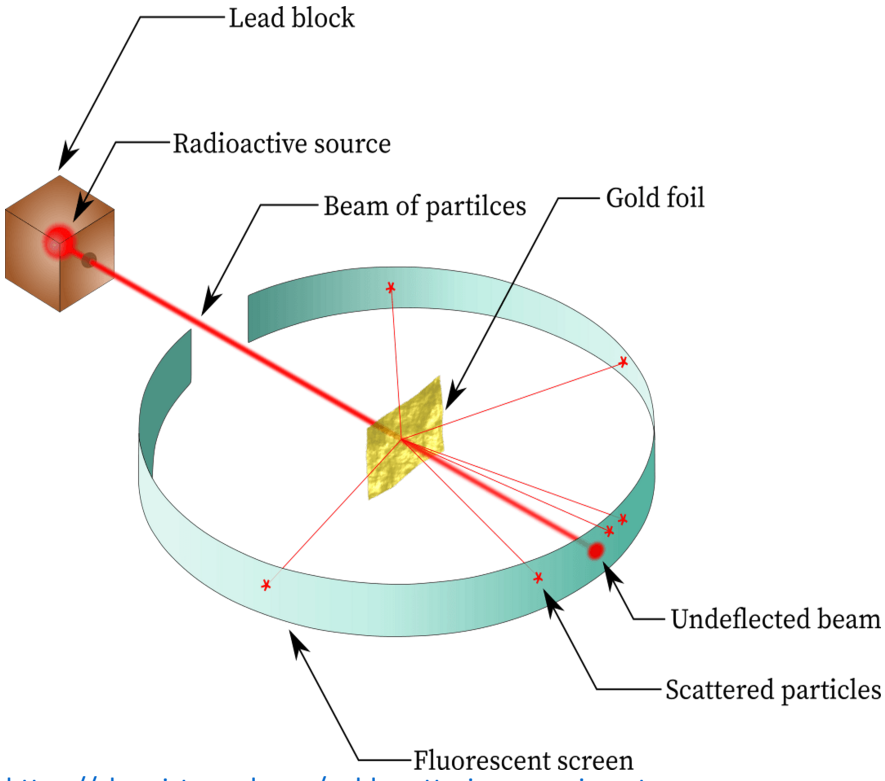
Atomic Physics

Monday, December 7, 2020 7:19 PM

5.1:
The Nuclear Atom

5.1.1:
Atomic Model

An atom is made up of **protons, neutrons and electrons.** The protons and neutrons are held together in the nucleus by strong nuclear force and the electrons orbit this positively charged nucleus.



https://chemistrygod.com/gold-scattering-experiment

An experiment conducted by Rutherford shaped the Atomic Theory as we know today. He shot alpha particles at a very thin gold foil. Alpha particles are positively charged.

What happen was at that period very revolutionary. Most alpha particles went through the gold path in one straight line whereas some deflected at acute angles, some absorbed but some were even reflected back. **This experiment then shows that atoms are mostly made up of positive space but has a very densely positively charged center.**

5.12:

Nucleus

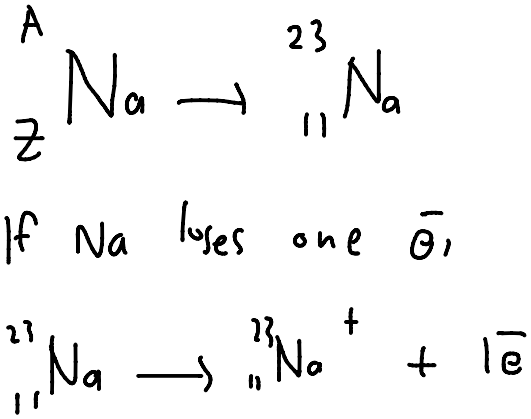
The nucleus, as previously described, is made up of protons and neutrons. Neutrons carry no charge. Although this veer more towards chemistry, it is nice to know that when we usually deal with atoms, electrons can be easily lost or gained but not protons or neutrons.

Protons and neutrons are attracted to each other by a very strong nucleus force whereas the electrons are attracted to the nucleus by electrostatic force which is this case, is relatively weak compared to SNF.

Particle	Mass(amu)	Charge
Proton	1	(+1)
Neutron	1	0
Electron	1/1836	(-)

The number of protons is denoted by Z whereas the nucleon number(proton + neutrons) is denoted by A.

Hence, take an example of sodium(Na).



With respect to the nucleus, since we have established the fact that it is held by a strong force, breaking it will require huge amounts of energy.

Nuclear fusion: It is when 2 or more unstable light nuclei combine together and release vast amount of energy.

Nuclear fission: It is when an unstable nuclei splits to 2 lighter nuclei, releasing vast amount of energy.

An example of nuclear fusion is what is happening with our sun. It combines hydrogen

isotopes to form a larger product, namely helium.

On the other hand, nuclear reactors involves nuclear fission. The split radioactive elements such as that of uranium.

Speaking of which, what are isotopes?

Isotopes are **atoms of the same element with the same number of protons but different number of neutrons**.

5.2:
Radioactivity

5.2.1:
Detection of Radioactivity

Background radiation refers to the radiation already around us from our surroundings. Examples include cosmic rays and natural rocks.

Photographic Film	Alpha	Beta	Gamma
Cloud Chamber	Alpha	Beta	Gamma
Spark counter	Alpha		
Gold-leaf electroscope	Alpha		
Geiger-muller tube	Alpha	Beta	Gamma

5.2.2:
Characteristics of 3 kinds of emission

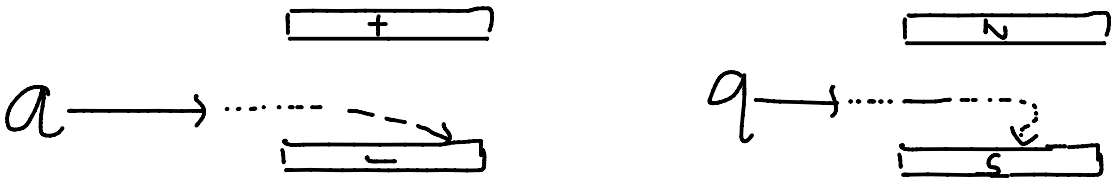
Radioactive emission occur randomly over space and time.

Emission	Nature	Ionizing effect	Penetrating ability
Alpha	1) Similar to Helium-4 2) Travels at 10% speed of light 3) Has 2 protons and 2 neutrons	Very ionizing hence cannot travel far	Very weak penetrating power due to strong ionizing effect
Beta	1) High energy electrons which are emitted when neutral atoms emits ionize to form a positively charged atom 2) Travels at 50% speed of light	Weakly ionizing	Medium penetration

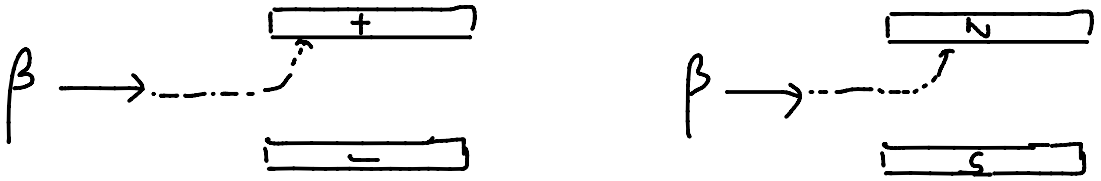
Gamma	1) High frequency but low wavelength 2) Part of the electromagnetic spectrum 3) Travels at the speed of light	Very weak ionizing effect	Very penetrating

Effect of magnetic and electric field on 3 emissions:

1) Alpha --> Since alpha particles are positively charged, if it passes through an electric field, it will be attracted by the negative plate. With respect to Fleming's Left Hand Rule, if it passes through a magnetic field, it will be deflected into the page



2) Beta --> Since beta particles are negatively charged, if it passes through an electric field, it will be attracted by the positive plate. With respect to Fleming's Left Hand Rule, if it passes through a magnetic field, it will be deflected out of the page



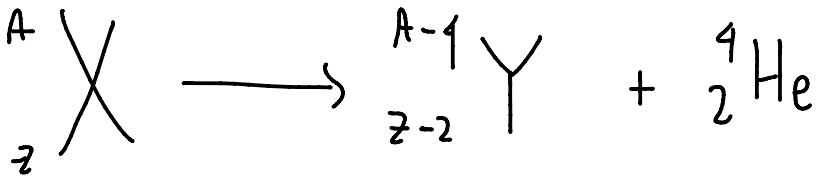
If you notice, the magnitude of deflection of beta particles are greater then that of alpha particles. The reason why is simple. An electron is incredibly light and hence are deflected way easier compared to alpha particles.

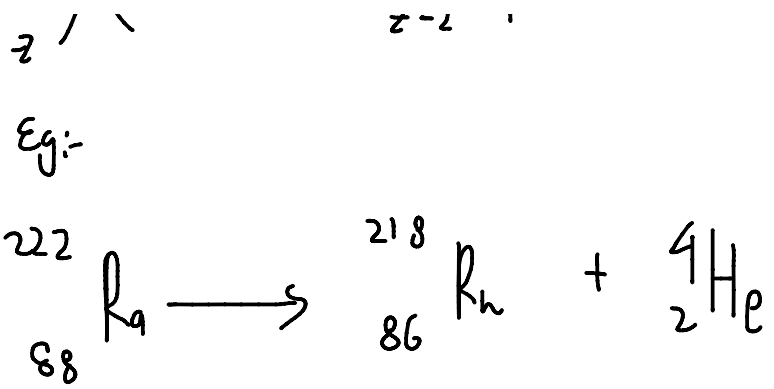
3) Gamma --> Gamma rays carry no charge and hence are not affected by magnetic or electric fields.

5.2.3:
Radioactive decay

Radioactive decay is the breakdown of an unstable nuclei. Although it is random, the probability is constant.

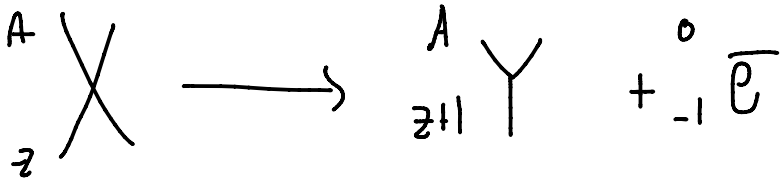
Alpha decay:

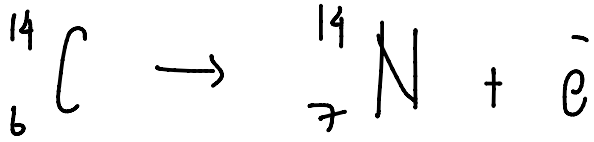




*take note that when decay occurs, a new element is seen (Ra --> Rn + He)

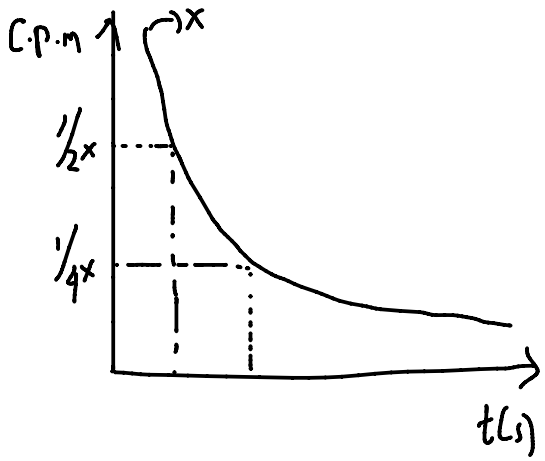
Beta decay:





5.2.4:
Half-life

The amount of radioactive particles emitted by a radioactive substance will decrease over time but will never reach zero. There is an inverse relationship between time and counts per minute(this is an indication of activity).



Hence, half life refers to the time that has elapsed for 1/2 of the nuclei to decay.

Elements have very varying half-lives. Some are just a few seconds and some extend to million of years.

Example problems on half-live:

If an isotope initially has a cpm of 500, determine its half-life if its cpm after 21 days is 3.9.

Initially, we have 500.

The traditional method is to divide 500 by 2 until 3.9 is reached. However, if we notice, the cpm of the isotope forms a sequence.

CPM: 500, 250, 125, 62.5 …

Hence, we can say that:

$500 \times 0.5^n = 3.9$

Where n is the number of times the isotope has been halved.

Hence, n = 7.

Understand that 7 is not the half-life but the number of times the isotope has been halved. Henceforth, since we know in 21 days, it has been halved 7 times, the half-life is 21/7 which is equal to 3 days.

Do take note that when questions involve background radiation(this type of questions will ask you the CPM after a certain time period), always subtract it first and then do the appropriate steps. Afterwards, add your final answer with background radiation.

5.2.5:
Safety Precautions

Prolong exposure to radiation can cause cancer and other severe health implications. It is always best to use lead as the material for storing radioisotopes.

Alpha emissions are stopped by a piece of paper and beta by 3mm of Aluminum.

Exam tips:

1) Understand how alpha, beta and gamma deflect when in a magnetic or electric field
2) Understand why beta deflects more than beta
3) Remember that with respect to the Left Hand Rule, one of the finger stands for current. Hence, alpha particles will travel in the same direction to the current but beta particles, being electrons, will travel the opposite direction
4) Practice problems with respect to half-life as this always appears and usually can be up to 4 marks
5) Practice the nuclide notation
6) Remember that the ionizing and penetrating ability have an inverse relationship